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NOTE.

The authors of the several papers contained in this volume are themselves accountable for all the statements and reasonings which they have offered. In these particulars the Society must not be considered as in any way responsible.

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Manchester Memoirs, Vol. liii. (1908), *No.* 1.

I. The Nature of the α Particle.

By Professor E. RUTHERFORD, F.R.S.,

AND

T. ROYDS, M.Sc.

Received and read November 3rd, 1908.

The nature of the α particle from radioactive substances has, for several years, been one of the most important questions in Radioactivity. The evidence as a whole indicates that the α particle is an atom of helium carrying a positive charge. Recent experiments of Rutherford and Geiger (*Proc. Roy. Soc.*, 1908) have substantiated this conclusion. An additional proof of the correctness of this point of view is afforded by the good agreement between the rate of production of helium calculated by Rutherford and Geiger, and the rate of production recently measured by Sir James Dewar (*Proc. Roy. Soc.*, 1908).

This evidence is, however, of too indirect a character to prove decisively that the α particle is an atom of helium. It might be possible, for example, that the expulsion of an α particle led to the liberation of helium from the active matter, but that the α particle itself was not an atom of helium. In order to give a definite proof of the identity of the α particle with a helium atom, it is necessary to show that helium can be obtained from accumulated α particles, quite independently of the active matter from which they are expelled. This has been done in the following way :—

Purified emanation, corresponding to the equilibrium

amount from 150 mgs. of radium, was compressed by raising a column of mercury into a fine glass tube about 1·5 cms. long. The walls of this glass tube were sufficiently strong to withstand atmospheric pressure but thin enough to allow the greater part of the expelled α particles to be fired through them. After a number of trials, Mr. Baumbach succeeded in blowing a number of such fine tubes for us. The emanation tube was surrounded by a larger cylindrical glass tube about 8 cms. long and 1·5 cms. diameter. This was first exhausted by a pump and the exhaustion completed by means of a charcoal tube immersed in liquid air. By means of another side tube connected with a mercury reservoir, the gases formed within the outside tube could be compressed into a small vacuum tube attached to the top and their spectra examined.

The tube containing emanation was about 1/100 mm. thick. The stopping power of the glass for the α particle corresponded to less than 2 cms. of air, so that the α particles expelled from the emanation itself, radium A and radium C escaped through the emanation tube, and were fired into the walls of the outer glass tube. Twenty-four hours after the introduction of the emanation, no trace of helium was detected on compression of the gases into the vacuum tube; at the end of two days the helium yellow line was seen faintly; after four days, the yellow and green lines came out brightly, and after six days practically the whole helium spectrum was observed.

An experiment was then made to test whether the helium observed could have *diffused* from the emanation through the thin glass walls. For this purpose, the emanation was replaced by about ten times its volume of helium and a new outer tube and vacuum tube placed in

position. No trace of helium was observed in the outer tube over a period of eight days. Emanation was again introduced, and after four days, the helium spectrum was again observed.

In these experiments, every precaution was taken to prevent possible contamination of the apparatus with helium. Freshly distilled mercury and fresh glass apparatus was used. No trace of helium was observed unless the emanation was introduced into the fine capillary.

This experiment affords a conclusive proof that the α particle after losing its charge is an atom of helium. Other evidence indicates that the positive charge on the α particle is twice that carried by the hydrogen atom.

Manchester Memoirs, Vol. liii. (1908), *No.* 2

II. Some Properties of the Radium Emanation.

By E. RUTHERFORD, F.R.S.

Received and read November 3rd, 1908.

In 1906 (*Nature*, Oct. 25), I drew attention to the fact that the emanations of radium, thorium, and actinium were completely absorbed by cocoanut charcoal at ordinary temperatures. I have had occasion recently to repeat these experiments with much larger quantities of radium emanation and have found that the actual volume of emanation capable of absorption by charcoal at room temperature is very small. For example, several grams of cocoanut charcoal are required to absorb completely the emanation from 200 mgs. of radium at ordinary temperature although the volume of the gas is only one-tenth of a cubic millimetre. As was to be expected, the absorptive power of charcoal for the emanation increases rapidly with lowering of the temperature. This was investigated as follows :—A quantity 0·8 gram of cocoanut charcoal, which absorbed about 4 c.cms. of air at the temperature of liquid air, was connected with a pump and the air completely removed by heating the charcoal. The charcoal was then surrounded by a pentane bath at -150° C., and the purified emanation from 83 mg. of radium (about ·05 cubic mm.) absorbed in it. As the temperature of the bath slowly rose, the unabsorbed emanation was allowed to expand into an exhausted receiver of about 50 c.cms. capacity. This was pumped out at different temperatures of the charcoal, and the emanation

collected and afterwards measured by the γ ray method. At -50° C. the amount of unabsorbed emanation was less than $\frac{1}{10}$ per cent of the total. Above -40° C., the emanation commenced to escape rapidly, and half had been pumped off at a temperature of 10° C. About 19 per cent. remained in the charcoal at 100° C., but practically all was released at a temperature of the softening of glass. It is seen from these results, that at 10° C. the charcoal absorbs about ·03 cubic mm. of emanation per gram. and at -40° C. about ·06 cubic mm. per gram.

An experiment was shown to illustrate the rapidity of condensation of pure emanation contained in an exhausted vessel when one point was cooled to the temperature of liquid air.

III. A Method of Calculating the Number of Degrees of Freedom of a Molecule among which the Partition of Energy is governed by the Principal Temperature.

By H. Bateman, M.A.

Read October 20th, 1908. Received for Publication October 23rd, 1908.

1. In the statistical mechanics of a system of molecules each of which has a definite number of degrees of freedom, there is a remarkable theorem due to Boltzmann* which establishes a law of equipartition in the average distribution of energy among the degrees of freedom.

The principal embodied in this law is apparently of very wide application, for it is easy to recall many instances in which there is equipartition in the distribution of different types of energy. For instance in a plane or spherical wave of light the magnetic energy is equal to the electric energy, and in many types of wave motion studied in the subjects of Hydrodynamics and Sound the Kinetic energy in a wave length is equal to the Potential energy.

In the case of a perfect gas Boltzmann's theorem leads to an equation expressing the ratio of the specific heats in terms of the number of degrees of freedom for

* It was enunciated by Waterston in a less general form in 1821 and rediscovered by Maxwell in 1859. Boltzmann's investigation was given in 1868 in the *Sitzungsb. der K. Akad. Wiss. Wien*, vol. 58, pp. 517-560. The subject was again taken up by Maxwell in 1879. *Camb. Phil. Trans.*, vol. 12, pp. 547-570; "Collected Works," vol. 2, p. 713.

which the energy is governed by the principal tempera ture. To a first approximation* the equation is

$$\gamma = 1 + \frac{2}{n} \tag{1}$$

where n denotes the number of degrees of freedom possessed by the type of molecule under consideration.

The validity of this equation has often been called into question† but the principal objections brought against it lose their force when the dissipation of energy is taken into account. (Jeans, *op. cit.*, pp. 188-196, 210-228.)

It appears that the degrees of freedom which must be taken into account in calculating the value of n, are those which allow for a permanent increase or decrease in the amount of energy allotted to them, when the state of motion of the molecule is suddenly changed. On this view the degrees of freedom which correspond to damped vibrations are excluded. When the molecule is considered as a dynamical system consisting of a large number of particles, the damped vibrations arise from a set of displacements of the system for which the existing state of motion is *stable*. The type of displacement which must be considered in calculating the value of n is one for which the motion of the system is either neutral or unstable.‡

Whatever view be taken with regard to the validity of equation (1) and other equations of a more general character, it is not without interest to examine whether a set of rules can be framed which will lead to a value of n for which the calculated value of γ agrees roughly with the experimental value. Various attempts have been made

* A general investigation is given by Jeans, in "The Dynamical Theory of Gases," ch. 10.

† E.g. *Nature*, Aug. 13, (1885), vol. 32, pp. 352, 533.

‡ It may be mentioned here that Lord Kelvin was of the opinion that a mode of vibration was not to be considered as a degree of freedom.

to connect n with the number of atoms in the molecule,* but the experiments of Capstick† and others indicate that the properties of the constituent elements must be taken into account.

A set of rules leading to numbers showing a fair agreement with the experimental ones, may be constructed on the hypothesis that an atom in a chemically active state possesses a number of degrees of freedom represented by 3+ the valency exhibited by the atom under the circumstances.‡ When a number of atoms are in a state of combination, the number of degrees of freedom of a molecule of the compound may be calculated by adding together the numbers that must be ascribed to each atom, and subtracting the number of conditions that must be satisfied in order that the geometrical relations peculiar to a stable configuration or state of motion may remain permanent.

To take a simple geometrical illustration we shall consider two ideal spherical atoms each of which contains a ring of electrons. In the state of combination we shall suppose that the system is stable when the spheres are in contact (one condition) and the planes of the two rings are parallel (two conditions). Thus in this ideal state of combination three geometrical conditions have to be satisfied if the stable state is to remain permanent, this involves a loss of three degrees of freedom for the combination.

When the molecules of a gas contain only one atom, as in the case of Mercury, Helium, Krypton, Argon, the

* Naumann, *Annalen der Chemie*, vol. 143, p. 284, 1867, also J. J. Thomson in Watts' "Dictionary of Chemistry," vol. 1, p. 89.

† *Phil. Trans.*, vol. 186, p. 564, 1895; vol. 185, p. 1, 1894.

‡ The author was led to make this hypothesis from considerations quite apart from the law of equipartition. An account of these will be given in another paper.

value of n must be taken to be three because the atom does not exhibit any valency *under the given circumstances.* It is true that the Mercury atom does exhibit a valency under different circumstances, because Mercury forms chemical compounds, but it does not exhibit a valency when the ratio of its specific heats is calculated, otherwise there would be more than one atom in the molecule.

We adopt in fact, the view that valency is essentially a relative property, and varies with the circumstances, but that for each element it has a maximum value.

The rules which are given here are essentially of a hypothetical character, so little is known of the geometrical relations, which two atoms bear to one another, when in a state of combination, that there is no definite information to start from, and we are bound to work backwards from the experimental values. The number of degrees of freedom possessed by a molecule is bound to enter implicitly in the numerical values of constants connected with chemical reactions, and deserves to be estimated just as much as the molecular weight.

These rules then are suggested as a working hypothesis from which to start ; it is claimed that the assumptions made are quite reasonable, and that the exceptional hypothesis made with regard to Chlorine in order to explain Capstick's results is adhered to throughout.

In general a relation involving the form and orientation of the groups of electrons contained in two atoms will be called a *valency relation*, and a relation specifying the distance apart of two atoms, or the nature of the orbit which one describes round the other a *distance relation.*

We shall suppose that a simple bond between two atoms is in general equivalent to two valency relations and one distance relation, that is three relations in all, in

some cases, however, a distance relation may not exist. Cl often appears to possess this peculiarity in certain states of combination.

The different types of relations between atoms and the equivalent number of conditions to be satisfied are considered in the following table. The number of degrees of freedom of various molecules are then calculated on the supposition that

the Carbon atom has 7 degrees of freedom since its valency is 4
Hydrogen „ 4 „ „ „ „ 1
Chlorine „ 4 „ „ „ „ 1

We shall denote the total number of degrees of freedom of the molecule by n.

Nature of Connection.		*Number of Conditions.*
Simple bond	——— ...	3
Double bond	═══ ...	5
Triple bond	≡≡≡ ...	7
Quadruple bond... ...	≡≡≡— ...	9
Simple bond without a distance relation ...	—— —— ..	2
Three atoms in one straight line... ...	$H \rightarrow C \leftarrow H$ ...	2
Four atoms in one plane	H_m H_m C_m ...	1
Two distances equal ...	H a a H ...	1
s distances equal ...	... ...	$s-1$
Two planes parallel ...	... ...	2
Two planes the same ...	... ...	3

2. *Calculation of the number of degrees of freedom of various molecules.*

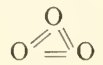
Hydrogen. If we assume the molecule to be represented by the formula

H—H. $n = 4 + 4 - 3 = 5$.

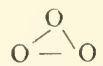
Chlorine. If the formula is assumed to be Cl – Cl, we get $n = 5$ which does not give a value of γ agreeing with the experimental one. If on the other hand we assume the formula to be Cl – – Cl, we get $n = 4 + 4 - 2 = 6$. The deviation of the value obtained by assuming $n = 5$, may, however, be due to the fact that Chlorine is far from being a perfect gas.

Oxygen. O = O. $n = 5 + 5 - 5 = 5$.

Ozone. O = O = O gives $n = 5 + 7 + 5 - 5 - 5 = 7$.



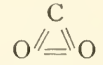
gives $n = 7 + 7 + 7 - 5 - 5 - 5 = 6$.



gives $n = 5 + 5 + 5 - 3 - 3 - 3 = 6$.

It is possible that the first form is intermediate in the formation of the second, so that in reality both types of values occur. The recognised value of γ is 1·29 which corresponds to a value of n lying between 6 and 7.

Carbon di-oxide O = C = O gives $n = 7$.



gives $n = 6$.

just as in the case of ozone. The experimental value of γ is about 1·3, which again corresponds to a value of n lying between 6 and 7. In this case also, it is possible that both kinds of molecules occur.

Marsh Gas

Fig. 6. $n = 7 + 16 - 12 - 5 = 6$.

Methyl Chloride

Fig. 7. $n = 7 + 12 + 4 - 9 - 2 - 2 - 2 - 1 = 7$.

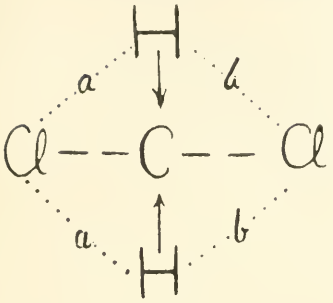


Fig. 1.

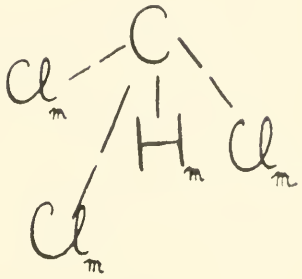


Fig. 2.

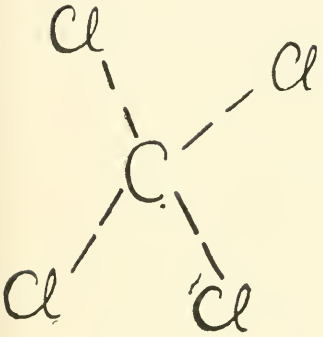


Fig 3

Fig. 4.

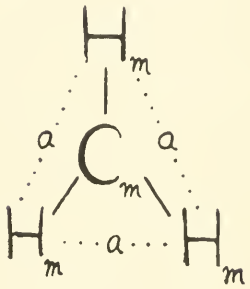


Fig. 5.

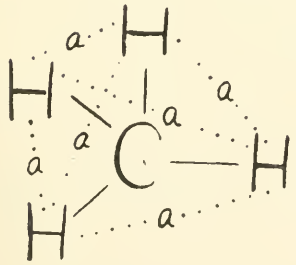


Fig. 6.

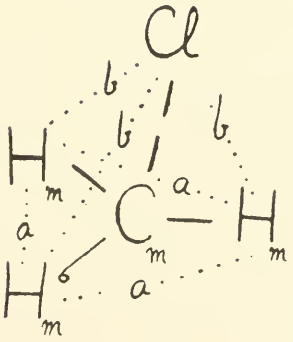


Fig. 7.

Methylen Chloride

Fig. 1. $n = 7 + 8 + 8 - 3 - 3 - 2 - 2 - 2 - 1 - 1 = 9.$

Chloroform

Fig. 2. $n = 7 + 4 + 12 - 3 - 6 - 1 = 13.$

Carbon tetrachloride

Fig. 3. $n = 7 + 16 - 8 = 15.$

CH_2 group

Fig. 4. $n = 7 + 8 - 3 - 3 - 2 = 7.$

CH_3 group

Fig. 5. $n = 7 + 12 - 9 - 2 - 1 = 7.$

Ethane

$CH_3 - CH_3$ $n = 7 + 7 - 3 = 11.$

Propane

$CH_3 - CH_2 - CH_3$ $n = 7 + 7 + 7 - 6 = 15.$

Butane

$CH_3 - CH_2 - CH_2 - CH_3$

$$n = 7 + 7 + 7 + 7 - 9 = 19.$$

C_sH_{2s+2} $n = 7s - 3(s - 1) = 4s + 3.$

Ammonia. $n = 6 + 12 - 9 - 2 - 1 = 6.$

In the COOH group, the four atoms can be supposed to set themselves in one plane. Taking then the structural formula to be

$$O = C - O - H$$

we get

$$n = 7 + 5 + 5 + 4 - 5 - 3 - 3 - 1 = 9.$$

Acetic Acid. Assuming that the geometrical relations may be roughly described by the formula

$$(CH_3) - (COOH)$$

we get

$$n = 7 + 9 - 3 = 13.$$

Methyl Alcohol ($CH_3 - OH$). If we assume as an approximation that the H in the OH group is equidistant from the other three, we get

$$n = 7 + 6 - 3 - 2 = 8.$$

In the CH_3 group, when one H atom is replaced by an atom or radicle having r degrees of freedom, the four

constituents can be supposed to roughly set themselves in one plane with the two H atoms equidistant from the radicle. This gives

$$n = 7 + 4 + 4 + r - 9 - 1 - 1 = 4 + r$$

Eg. $CH_3-(CH_2-O-H)$. $n = 7 + 6 + 4 - 3 = 14$.

Table giving the calculated and experimental values of γ.

Molecule.	*Degrees of Freedom.*	*Calculated* γ.	*Experimental* γ.
H_2	5	1·4	1·3977
Cl_2	6	1·333	1·323
O_2	5	1·4	1·39
O_3	6 7	1·333 1·286	1·29
CO_2	6 7	1·333 1·286	1·3
CH_4	6	1·333	1·313*
CH_3Cl	7	1·286	1·279*
CH_2Cl_2	9	1·22	1·219*
$CHCl_3$	13	1·154	1·150
CCl_4	15	1·133	1·130*
C_2H_4	7 9	1·286 1·22	1·264*
C_2H_6	11	1·182	1·182*
C_3H_8	15	1·133	1·130*
C_4H_{10}	19	1·105	1·108
NH_3	6	1·33	1·328
CH_4O	8	1·25	1·25
$C_2H_4O_2$	13	1·153	1·146
C_2H_6O	14	1·143	1·14

* These numbers are from a paper by Capstick, *Phil. Trans.*, vol. 186, p. 564, 1895, vol. 185, p. 1, 1894.

IV. Notes on the Spawning of *Eledone* and on the Occurrence of *Eledone* with the Suckers in Double Rows.

By F. H. Gravely, M.Sc.

(Received and read November 17th, 1908.)

Spawning.

The spawning of *Eledone* has been described by Joubin (1888), and also, I believe, by Korschelt (1893), though I have not seen the latter paper.

The process rarely occurs in captivity however, and so an account of it, as I saw it at the Port Erin Aquarium this summer, may be of some interest, although I can do little more than confirm Joubin's description. Shortly after my arrival at Port Erin early in July, I noticed a cluster of eggs attached to the glass of the *Eledone* tank in the Aquarium. A little later a fine large specimen of *Eledone* was seen completing the arrangement of another cluster; this specimen was at once placed in a separate tank in order that it might be distinguished from the others and carefully watched. It continued to produce from one to four bunches of eggs almost every day for about a month; towards the end of that time the spawning became less frequent and soon ceased altogether. It usually occurred, as noticed by Joubin, in the morning and evening; and the eggs were soon destroyed if left in the tank with the parent and fish. The clusters (*Fig.* 8*a*) were much larger than the one figured by Joubin, though the individual eggs were of about the same size: probably he studied some species other than the common British *Eledone cirrosa*. The eggs are pear-shaped, the narrow

end being drawn out into a stalk whose free end is incorporated into the central common stem of the bunch ; they are white, and opalescent. The yolk does not extend quite to the pointed extremity (*Figs.* 7-8). The eggs are all about 7 mm. long × 2·5 mm. maximum breadth. The bunches are usually of about the same form and size as the one seen in *Fig.* 8*a*, and are fastened to some hard substance (in this case either the glass or concrete sides of the aquarium) by a disc attached to the main stem. Occasionally, however, this disc was of greater extent and the eggs attached to it singly (*Fig.* 8*b*). These clusters contain fewer eggs than do those with a central common stem.

Four of the bunches produced were preserved in formalin ; the rest were removed and placed in one of the hatchery tanks with a good supply of sea-water running through it. After about a month there seemed to be a slight diminution in the amount of yolk present, and some eggs broke off from their stalks ; but they showed no other signs of change. On the only occasion when I was fortunate enough to see the actual commencement of the processes involved in the production of a bunch of eggs, I began to watch the specimen, which was then adhering to the glass front of the tank, about two hours before the eggs appeared. During this time the small suckers near the mouth showed a strong tendency to stretch out and adhere to one another, as though in anticipation of receiving the eggs. After some time—probably about an hour, but the exact period was unfortunately not noted—several violent waves of contraction passed over the body from behind forwards, and the siphon directed a jet of water into the oral funnel. Later on, the two lateral pairs of arms were thrust into the mantle-cavity, and pressed hard against the mantle as they moved about inside, whilst the

ventral arms were coiled together and pressed firmly against the posterior end of the body, the dorsal pair being held loosely back over the head. As the lateral arms were withdrawn from the mantle-cavity, they and the other two pairs of arms exhibited a most extraordinary activity in the form of an extremely rapid spiral twirling.

It is possible that these movements, and the intermittent placing of the small suckers near the mouth in position for the reception of the eggs, may have been due to some difficulty in oviposition having arisen as the result of captivity; for very few specimens seem able to produce their eggs at all in captivity, a large number of females dying in an egg-bound condition.

Joubin (*loc. cit.*, p. 159) states that these movements were followed, in the cases he watched, by the almost immediate production of the eggs. In this instance, however, it was not so, and eventually, after altogether about one and a half hours apparently futile waiting, I left the aquarium to return to my work in the laboratory, returning occasionally to see whether there were any further signs of impending spawning.

After about half an hour I had the good fortune to find the specimen under observation crawling sideways across the glass front of its tank, and to see it come to rest adhering to the glass by its large suckers, whilst the mouth was withdrawn from the glass to the narrow extremity of a funnel-shaped depression thus formed between the bases of the arms; across the broad opening of this depression the small proximal suckers would stretch out to clasp one another and then restlessly draw back again.

Four or five jets of water were directed through the siphon into this oral funnel, no doubt to insure its absolute freedom from all obnoxious materials, and the proximal

suckers then closed over it completely. The siphon was at once extended so that its distal end passed between the two ventral arms, under the clasped suckers, and so inwards till it must have been close to the mouth; it was held in this position for a few moments, during which the eggs and a glutinous material must have been conveyed through it to the oral funnel; and directly it was withdrawn the proximal suckers began pressing the glutinous material upon the glass to form the disc for the attachment of the bunch, and a few of the eggs appeared from behind them.

As the remainder of the processes connected with the formation of the bunch had been seen already several times, the animal was disturbed at this stage in order to find out how the eggs were then arranged. As it drew back they were left, already in a cluster (*Fig.* 7), attached by its upper end to the glass of the aquarium. When removed, the whole bunch was found to be extremely glutinous, holding together and sticking readily to my fingers, and eventually to the cork on to which I pressed the attachment plate that had already been somewhat indefinitely formed out of the glutinous material. The eggs were hanging in a matrix of this same material; they were all arranged stalk uppermost, but the free ends of the stalks were not yet fastened together to form a common stem for the whole bunch. As it seems hardly possible that so many eggs should have been placed in position in the extremely short time that passed between the time of their entering the oral funnel and the time when the mother was driven away from them it may safely, I think, be concluded that they all passed through the siphon with their stalks pointing in the same direction. They in no way differed from the eggs of a completed bunch in appearance when laid, but since they were preserved in

formalin they have turned a dirty, brownish colour. This has not happened to the eggs of any of the three completed bunches preserved.

On several occasions the completion of the bunch was watched from the point at which this one had arrived when the parent was disturbed. The proximal suckers, after forming the attachment-disc by pressing some of the glutinous substance on to the glass, proceed to press on to this the free ends of the stalks of the nearest eggs; moreover, they press the ends of these stalks together to form the commencement of the common stem of the bunch, and then incorporate into it the ends of the stalks of the eggs a little further back, and so on, the whole of the bunch gradually passing into view from amongst the suckers as it is formed. The eggs are moved about individually, and apparently with great deliberation, by the suckers in their immediate neighbourhood; but I was unable to distinguish any rotation or other definite type of movement that might in any special way have helped in the formation of the central cord of threads.

When the bunch has passed completely into view it is held firmly against the glass for a short time between the two posterior arms which are extended one on each side of it as if to ensure the adhesion of the different threads composing the central stem. At about the same time the siphon begins to move about vigorously from side to side, and water appears to be blown through it with considerable force. When the manipulation of the eggs is finished, two or three strong jets are directed full on to them at short intervals. The arms then again display the vigorous spiral twirling already described as occurring some time previous to the production of the eggs; this movement may also be occasionally seen in specimens that are not

spawning at all. Finally one arm becomes less active than the others and its distal slender portion is wrapped round the bunch of eggs, the firmness of which it appears to test as the unusual activity of the other arms disappears and the creature moves away. The process from the the time at which the mother finally settles upon the selected spot, to the time at which she leaves the finished bunch of eggs occupies from about fifteen to twenty minutes. Occasionally the concluding twirling of the arms and testing of the security of the bunch of eggs are omitted.

When the eggs are left by the mother the whole of the bunch is colourless; during the first day, however, the attachment-disc and central stem become green, no doubt through the growth of some microscopic alga upon them.

The specimen whose spawning habits I watched always attached its eggs near to the front of the tank—usually on the glass itself—at a depth not exceeding two feet, and usually well under that. Another specimen in the next tank produced two or three bunches of eggs, and attached them all to the back wall of the tank (furthest from the light), at a depth of about three feet.

All the specimens of *Eledone* that had been associated with the female under observation have since been preserved by Mr. Chadwick, and sent by him to Manchester, where their sex has been determined by Miss Isgrove. They have all proved to be female, so it is certain that the eggs, if fertilized at all, were fertilized by sperm supplied to the female before her capture.

Arrangement of the Suckers.

The last specimen sent here by Mr. Chadwick I took to Dr. Hoyle for examination of the arms previous to the dissection of the genital ducts. He at once pointed

out to me that the suckers of each arm were arranged in two rows, as in the genus *Octopus,* and not in a single row as in *Eledone.* The general appearance of the animal, however, was distinctly that of *Eledone.* An examination of the radula of this specimen, and a comparison of it with those of an undoubted *Eledone* and *Octopus*, proved conclusively that it was *Eledone* as originally supposed. The comparative size, form, and arrangement of the teeth of the radula of *Eledone* (from the specimen with two rows of suckers) and of *Octopus* is shown in *Figs.* 5-6. Their size, form, and arrangement in the normal *Eledone* examined is identical with that found in the abnormal specimen ; also the smooth margin of the ribband is very much wider in the two specimens of *Eledone* than it is in *Octopus.*

The arrangement of the suckers on one arm (the right one of the ventral pair) of each of the same three specimens is shown in *Figs.* 1-3. The slight irregularities in the arrangement of the suckers of the *Octopus* have been somewhat exaggerated ; it will be seen, however, that they form two very distinct rows. In the abnormal *Eledone* the distinctness of the rows is not so marked, though it is more marked in the actual specimen in which the suckers are closely crowded together, than in the figure which is somewhat diagrammatic and shows them a little more spread out ; the distinctness of the two rows is most marked towards the end of the arm. In the normal *Eledone* there is a single row of suckers arranged here and there in a zig-zag manner so as to form two rows ; in the few specimens I have examined I have been unable to find any arm in which the single row of suckers was not interrupted in this way at intervals. Mr. Chadwick, however, in a letter to me in connection with this enquiry says: "This morning I have examined all our

preserved specimens, and have found three in which the arrangement of the suckers agrees exactly with that in my specimen of *E. moschata*"—a specimen from Naples of which he says: "The suckers on all its arms are in a single straight row from base to tip, and there is no sign of a zig-zag arrangement." He adds, "In three others the uniserial arrangement extends but a short distance from the mouth, and is replaced by the zig-zag arrangement which extends to the tip of the arm. The suckers of our two living specimens are so arranged. When the arm is strongly contracted they do not become biserial like the undoubted *Octopus*, nor do they become strictly uniserial like those of the undoubted *Eledone* when the arm is extended to its fullest capacity." Of these two living specimens, one is that of which the spawning is described above. Mr. Chadwick has sent me a diagram of the arrangement of the suckers on the basal portion of its arms, and with his permission I reproduce it here (*Fig.* 4). He says of it, "The alternating arrangement of the suckers begins about the point at which the arm becomes free from the interbrachial web, but it is much less apparent when the arms are fully extended. I should call it a single alternating row." This description would probably also apply to the abnormal form, except that as will be seen by reference to *Fig.* 1, the alternation extends right to the base of the arm.

A careful examination of an arm of *Octopus*, especially of the distal portion, shows that its two rows of suckers are simply an exaggerated form of this condition; for their peduncles present the appearance of a single row of which alternate members extend in opposite directions, and are held in this position by having partially fused with that portion of the arm across which they extend.

Dr. Hoyle has already pointed out (1886: p. 76) that in *Octopus* the double row of suckers is really due to the zig-zag displacement of a single row, and has further (1904: pp. 18-20; Pl. 5, Figs. 3-9) described some young specimens which he refers to this genus, in which the suckers appear sometimes in one row and sometimes in two.

Special interest attaches to the settlement of the question of the possible occurrence of two rows of suckers in *Eledone*, in that it may explain certain insufficiently authentic records of *Octopus vulgaris* in British seas, further north than the northern limit of its known distribution.

In conclusion, I must thank Dr. Hoyle and Mr. Chadwick for the valuable help that they have given me in connection with this paper.

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1886. JOUBIN, L. "La Ponte de l'*Elédone* et de la Sèche." *Arch. Zoöl. exper.*, ser. 2, vol. 6, pp. 155-163; text-fig., p. 157.

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1904. HOYLE, W. E. "'Albatross' Cephalopoda." *Bull. Mus. Comp. Zool.*, vol. 43, p. 1-71, pl. 1-12, 1904.

EXPLANATION OF PLATE I.

Fig. 1. Ventral right arm of *Eledone cirrosa** with the suckers arranged in two rows. ($\frac{2}{3}$ nat. size.)

Fig. 2. Ventral right arm of *Eledone cirrosa** with the suckers arranged in one row a little irregularly. ($\frac{2}{3}$ nat. size.)

Fig. 3. Ventral right arm of *Octopus vulgaris* to show the arrangement of the suckers in two rows. ($\frac{2}{3}$ nat. size.)

Fig. 4. Proximal part of an arm of *Eledone cirrosa* with the suckers of the oral funnel in a single row, those beyond the interbrachial membrane in two rows. (From a diagram kindly supplied by Mr. H. C. Chadwick, Curator of the Port Erin Marine Biological Station.)

Fig. 5. A row of teeth from the radula of *Eledone cirrosa*. The number of denticles on each side of the median tooth varies from 2 to 3. (× 23.)

Fig. 6. A row of teeth from the radula of *Octopus vulgaris*. The number of denticles on each side of the median tooth varies from 1 to 2. (× 23.)

* The specimens from which these figures were taken have been deposited in the Manchester Museum.

Fig. 1.

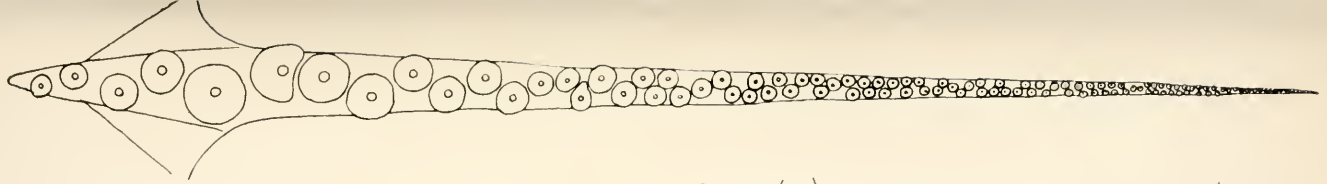


Fig. 5.

Fig. 2.

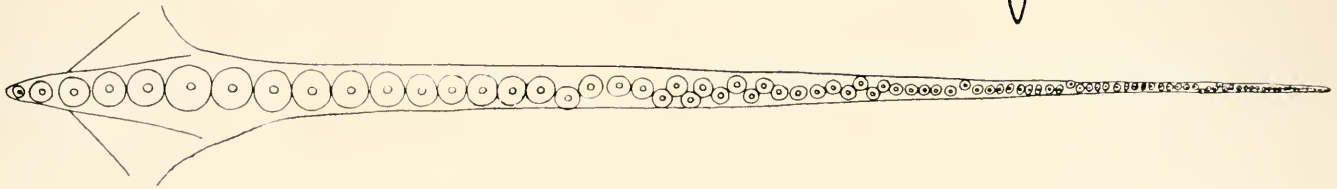


Fig. 4.

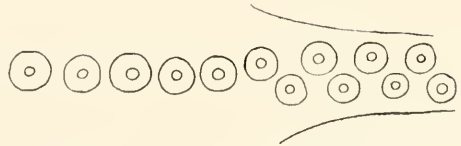
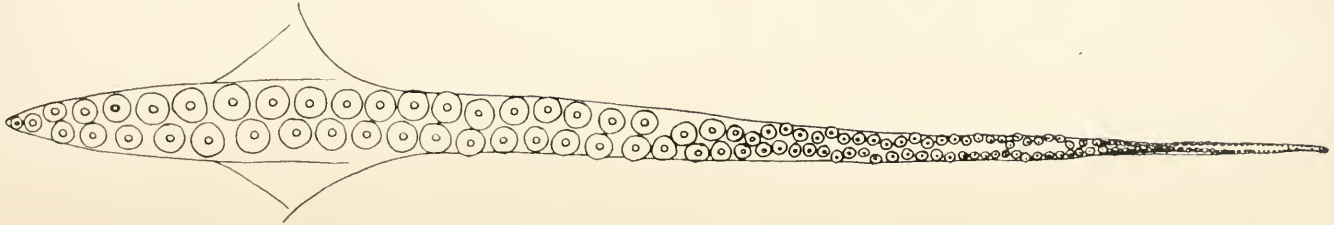


Fig. 6

Fig. 3.



EXPLANATION OF PLATE II.

Fig. 7. Cluster of eggs* of *Eledone cirrosa* after attachment to the glass of the aquarium, but before their arrangement into a bunch with a central stem. (Nat. size. From a photograph.)

Fig. 8. (*a*) A similar bunch completed*; the central stem is seen in two places as a dark body between the eggs; the attachment disc is also dark, and does not show up against the black background. (*b*) An abnormal cluster* in which the eggs are attached singly to an unusually large disc. (Nat. size. From a photograph.)

* The specimens from which these figures were taken have been deposited in the Manchester Museum.

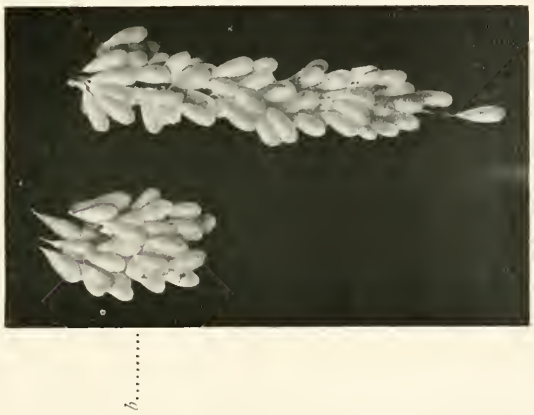


Fig. 8.

Fig. 7.

Manchester Memoirs, Vol. liii. (1908), *No.* 5.

V. On the Local Intensification of Draught produced in a Horizontal Air Current by the Presence of an Inclined Rod.

By A. H. Gibson, M.Sc.

Received November 6th, read November 17th, 1908.

Among the many superstitions and beliefs which have been handed down to the modern housewife from the remote past, one of the most interesting and most generally believed is that a poker, placed with its lower end against the fender and the other end reared against the bars of an ordinary firegrate without actually touching the fire, has magical properties in inducing a recalcitrant fire to burn up or to burn less smokily.

The only explanation of it ever given to the author, is evidently almost as old as the custom itself, dating back from a time when the devil and his attendant demons took a more immediately personal interest in household economics than is the case in the present prosaic age. It attributes the beneficial effect to the fact that the poker when so placed forms the sign of the cross with the fire bars, this driving away the evil spirit to whose influence the behaviour of the fire is of course due. While perhaps not altogether satisfying to one of a modern scientific school of thought, this explanation is not without interest.

The idea that there might, after all, be some scientific basis for the old belief first occurred to the author one evening when, standing in front of a smoky fire, he chanced to rest the end of the poker on the upper bar

of the grate, its upper end being well out in the room. Under these circumstances the presence of a distinct current, travelling upwards and outwards along that side of the poker nearest the fire, became apparent, being made visible by the smoke which was drawn from the fire at the tip of the poker and travelled up to within one or two inches of its upper end before breaking away.

This suggested the possibility and indeed the probability of a similar current being produced when the poker is inverted. If such is the case, and if the draught or velocity of inflow of the air is thereby locally increased to any appreciable extent, its efficiency for the purpose outlined must be granted.

The matter seemed so interesting that an attempt was made to test this by measuring the velocity of inflow at various points with and without the poker in position.

For this purpose a small "Reynolds" differential draught gauge was prepared and was used in connection with a double Pitot or Darcy's tube. The draught gauge uses oil, s.g. ·90, and water as its working fluids, 7·5 inches of a movement of their surface of separation being equivalent to a difference of pressure of 1 inch of water. The Darcy gauge consists of two fine glass tubes ·05″ outside diameter, with extremely thin walls and bent so that their orifices face in opposite directions and are in parallel planes ·7 of an inch apart. When placed parallel to the current this gives a direct measure of $k\frac{v^2}{g}$, where v is the velocity of the current, and k, though not determined for this gauge, is probably not far from unity.

On testing the combination it was, however, found to be insufficiently sensitive to give an indication of the draught in front of the fire great enough to enable any quantitative observations to be made, while the

attempt to obtain accurate readings within a few inches of a fire purposely made up to the utmost capacity of the chimney with a view of increasing the draught, was not unaccompanied by some discomfort.

The research was then transferred to the engineering laboratories of the Manchester University, where a blower for producing a blast for the forge fire, and driven fairly steadily from the main line shaft, was available for draught production.

From this blower a pipe was taken to a convenient bench and was arranged to discharge its blast horizontally. At some distance in front of this the poker, which was $\frac{5}{8}''$ diameter, tapering down to $\frac{9}{32}''$ in a length of 5 inches at its upper end, was clamped at its lower end in a retort stand, while a light wooden frame 6″ square and divided into $\frac{1}{2}''$ squares by means of very fine wires, was clamped at right angles to the poker and at any required position relative to the latter.

The Pitot tube was then used to explore the middle point of each of these squares, the end of the tube nearest the blast being held in the plane of the frame. In each case the reading of the gauge was taken with the tube at a given point first with and then without the poker in position, and the direction of the tube was adjusted so as to ascertain the maximum velocity at this point in each case.

The results of the experiments proved somewhat startling, for although it was anticipated that the effect of the poker would be marked, the magnitude of this effect was most surprising.

Details of these experiments are as follows :—

The results have been entered in diagrammatical form, the diagrams representing the portion of the frame in the neighbourhood of the poker, the tip of the latter

being at the level represented by the central circle in each case. The three numbers in each square refer to the readings taken at the centre of the square, the first and second being the gauge readings respectively with and without the poker in position, while the third gives the ratio of the square root of these two, and therefore the relative velocity of flow with and without the poker.

Experiment I.

Poker inclined at 50° to horizontal with its tip in the plane of the frame. Blast pipe horizontal, $1\frac{1}{2}$″ below level of, and 19″ behind tip of poker.

·44 ·41 1·04	·57 ·52 1·05	·57 ·51 1·06	·39 ·42 ·98
·91 ·74 1·11	·91 ·81 1·06	·77 ·61 1·13	·52 ·47 1·05
1·06 ·93 1·07	·98 ·92 1·03	·91 ·82 1·06	·74 ·41 1·34
1·07 ·92 1·08	·90 ·85 1·03	·80 ·67 1·09	·86 ·45 1·35

Experiment II.

Conditions as in I., but with poker moved 1″ nearer blast pipe and away from frame.

·47 ·40 1·08	·67 ·52 1·14	·67 ·51 1·15	·38 ·26 1·21
·37 ·29 1·13	·85 ·80 1·03	·88 ·75 1·09	·53 ·50 1·03
·65 ·56 1·08	1·04 ·88 1·03	1·10 1·05 1·02	·88 ·75 1·09
·67 ·60 1·06	1·26 1·30 ·985	1·17 1·30 ·95	·93 ·90 1·02

Experiment III.

Poker inclined at 38° to horizontal, with its tip in the plane of the frame. Blast pipe horizontal, 2·75″ below level of, and 16·5″ behind tip of poker. Blast much weaker than in I or II.

·20 ·12 1·29	·21 ·15 1·18	·16 ·11 1·20	·16 ·14 1·07
·24 ·15 1·27	·30 ·19 1·26	·31 ·20 1·25	·23 ·17 1·16
·38 ·21 1·35	·50 ·26 1·39	·45 ·27 1·30	·40 ·27 1·21
·73 ·44 1·29	1·10 ·57 1·39	·97 ·47 1·44	·65 ·41 1·26

Experiment IV.

Conditions exactly as in III., but with weaker draught.

·05 ·04 1·12	·10 ·06 1·29	·08 ·05 1·27	·05 ·04 1·12
·10 ·07 1·20	·15 ·07 1·47	·08 ·05 1·38	·05 ·035 1·20
	·25 ·19 1·15	·28 ·23 1·11	
	·70 ·55 1·13	·75 ·63 1·09	
	·97 ·97 1·00	1·05 ·98 1·03	

Experiment V.

Conditions as in III. and IV., except that poker is moved $\frac{1}{2}''$ nearer blast pipe and from frame. Weaker draught than in III. and IV.

·10 ·08 1·12	·04 ·02 1·41	·02 ·01 1·41	·01 ·01 1·0
·26 ·13 1·41	·10 ·04 1·57	·10 ·03 1·83	·11 ·05 1·48
·40 ·16 1·57	·36 ·12 1·73	·37 ·12 1·74	·23 ·14 1·28
·42 ·28 1·23	·66 ·37 1·47	·74 ·38 1·48	·76 ·41 1·51

From these results it is clear that in practically every case the draught, over the region explored, was very sensibly increased by the presence of the poker, the proportional effect being greater with the smaller inclination. The effect was even more marked at a short distance past the tip of the poker than in the plane containing the tip.

In Experiment V., where the proportional increase was greatest and amounted to as much as 83%, the intensity of the draught was less than in any other experiment,

and it will be noticed that this increase becomes generally more marked as the intensity is reduced. It seems reasonable to infer from this that the proportional increase will be at least as great, and probably much greater, when the intensity is reduced to the amount obtaining in front of an ordinary fire grate.

In Experiment V. the average increase, over a circle of 2″ diameter having the poker as centre, was practically 50%, and even if the local increase in front of the fire grate is no greater than this, it would certainly, under favourable conditions, be more than sufficient to account for the beneficial effect of the poker.

The explanation of the phenomenon would appear to be found in the fact that when a current of air impinges on a fixed body, eddies are formed on its leeward side, where a region of low pressure (below that of the atmosphere) in consequence exists. There is a tendency to inward flow towards this from all surrounding regions, accompanied by a consequent inward and upward flow towards and along the under side of the poker and towards the fire, this taking place along its whole length, but particularly from its lower end which is shielded from the direct influence of the draught.

In addition to this the air which is deflected by immediate contact with the upper surface of the poker tends, in virtue of its viscosity, to induce a secondary current in the same direction in the surrounding air.

The net result of these combined actions is that a larger volume of air passes the region immediately surrounding the poker, than when the latter is not in position, its direction of flow being brought more nearly parallel to the latter. At the same time the intensity of flow at points more remote is, of course, correspondingly reduced.

The action becomes very apparent if a sheet of blotting paper moistened in sections with liquid ammonia and with hydrochloric acid be wrapped tightly around the poker, the dense white fumes which are then given off enabling the direction and apparent velocity of the current to be readily observed.

Under the conditions already described such observations showed that with a gentle horizontal blast and with a poker inclined at 50° this directive influence was felt over a region apparently about 3″ in diameter, extending from about $\frac{3}{4}$″ above to $2\frac{1}{4}$″ below the poker. Over this region the mean direction of the draught was inclined at about 30° to the horizontal.

VI. On the Production of White Ferrous Ferrocyanide.

By R. L. Taylor, F.C.S., F.I.C.

Received and read December 15th, 1908.

It is well known that a solution of a ferrous salt, if it can be obtained free from even a trace of a ferric salt, gives a white precipitate when a solution of potassium ferrocyanide is added to it. But there is such great difficulty in obtaining a ferrous solution entirely free from ferric that very few chemists have ever seen pure white ferrous ferrocyanide. The precipitate usually obtained is a blue one—lighter or darker in colour according to the amount of ferric salt present—and consists of a mixture of the white ferrous compound with more or less Prussian blue, which is the very dark blue precipitate produced by the action of ferrocyanide of potassium on a ferric solution. None of the ordinary reducing agents will deprive a solution of a ferrous salt of all trace of ferric; but the author finds that a small amount of a solution of "hydrosulphurous acid" (more correctly the genuine "hyposulphurous acid," $H_2S_2O_4$) will accomplish this. The acid (mixed with some of its zinc salt) is easily prepared by shaking up for a minute or two a solution of sulphur dioxide in water with zinc "dust," and filtering the liquid. Or a dilute solution of sodium hydrosulphite, $Na_2S_2O_4$* may be used. The addition of either of these to an

* Sodium Hydrosulphite is now a commercial substance, and is made in considerable quantities. It is patented by the Badische Company Limited under the name of "Blankit." In the solid state it appears to be fairly stable, but it soon decomposes when in solution in water.

ordinary solution of ferrous sulphate reduces it so completely that a creamy white precipitate is produced on the addition of potassium ferrocyanide. Or a few drops of either solution will change the ordinary light blue precipitate into white; indeed they are such powerful reducing agents that they will turn Prussian blue perfectly white.

If there is no appreciable excess of hydrosulphite present with the white precipitate, it immediately begins to turn blue at the top, where the air has access to it.

The white precipitate provides an admirable way of showing the presence of dissolved oxygen in ordinary water. If water which has been previously well boiled, to expel dissolved air, is added to some of it there is no change; but ordinary tap water turns it blue instantly. To ensure success in this experiment there must not be any excess of the hydrosulphite present. Probably this reaction might be adapted to the determination of the amount of dissolved oxygen in water.

PROCEEDINGS

OF

THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

General Meeting, October 6th, 1908.

Professor H. B. Dixon, M.A., F.R.S., President, in the Chair.

Mr. A. H. Gibson, M.Sc., Assoc.M.Inst.C.E., Demonstrator and Assistant Lecturer in Engineering in the University of Manchester, was elected an ordinary member of the Society.

Ordinary Meeting, October 6th, 1908.

Professor H. B. Dixon, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables. The following were among the recent accessions to the Society's Library :—"*First Report on Research Work...on the Vitality of the Typhoid Bacillus in artificially infected samples of raw Thames, etc., water*," by A. C. Houston (fol., London, 1908), and "*Reports of Committees to be considered at a Meeting of the Board...17th July, 1908*" (fol., London, 1908), presented by the Metropolitan Water Board; "*The Radioactive Substances*," by W. Makower (8vo., London, 1908), presented by the author; "*Hope Reports*," ed. by E. B. Poulton, vols. 1-6 (8vo., Oxford, 1897-1908), presented by Dr. Henry Wilde, F.R.S.; "*National Antarctic Expedition, 1901-04, Meteorology, Pt. I.*," and "*Physical Observations*," 2 vols. (fol., London,

1908), presented by the Royal Society of London; "*Key to the Classifications of the Patent Specifications of France, Germany, etc.*," 2nd ed. (16mo., London, 1905); "*Subject List of Works on the Fine and Graphic Arts*"...(16mo, London, 1904), "*Class List and Index of the Periodical Publications...*," 2nd ed. (16mo., London, 1906), "*Subject List of Works on Agriculture, etc.*" (16 mo., London, 1905), "*Subject List of Works on Heat and Heat-engines*" (16mo., London, 1905), "*Subject Lists of Works on Aerial Navigation and Meteorology*" (16mo., London, 1905), "*Subject List of Works on Military and Naval Arts*" (16mo., London, 1907), "*Subject List of Works on the Laws of Industrial Property*" (16mo., London, 1900), "*Subject List of Works of Reference, Biography, Bibliography, etc.*" (16mo., London, 1908), presented by the Patent Office, London; "*Monthly Mean Values of Barometric Pressure for 73...Stations*"... (fol., London, 1908), presented by the Solar Physics Committee, London; and "*Canada's Fertile Northland*," with "*Maps*," 2 vols. (4to., Ottawa, 1907), presented by the Minister of the Interior, Canada.

The PRESIDENT submitted to the members the following Address of congratulation to the University of Oxford, to be presented by him to that body on October 8th, the occasion of the celebration by them of the Jubilee of the Oxford University Museum:—

To the Vice-Chancellor of the University of Oxford.

"We the Council of the Manchester Literary and Philo-"sophical Society, desire to offer to the University of Oxford "our greetings and congratulations on the celebration of "the Jubilee of the University Museum.

"Meeting, as our Council does, in the workroom of "John Dalton, we think it not unfitting to recall that the "concepton of the chemical elements on which Dalton "founded his Atomic Theory, originated with Robert Boyle "at Oxford; and that the recognition by chemists of the "diatomic molecules of Avogadro (which reconciled the "conflicting views of Dalton and of Gay-Lussac) was largely

"due to the work carried out by Brodie in the Chemical "Laboratory of the Oxford Museum.

"We have watched with the keenest interest the exten- "sions of the Oxford Museum and the widening scope of its "activities and usefulness; we are glad to recognise that this "increase accompanies and symbolises the growth in Oxford "of a new sympathy for scientific study and research, which "now take their place, honoured and giving honour, side by "side with the older learning."

Signed

On behalf of the Manchester Literary and Philosophical Society.

President.

Sept. 29th, 1908. *Honorary Secretaries.*

The terms of the address, and the offer of the President to represent the Society were unanimously approved of.

Addresses were given by Professor H. B. DIXON and Professor E. RUTHERFORD on matters of interest in connection with the meeting of the British Association at Dublin.

Professor DIXON briefly reviewed the work of the Chemical Section, making special reference to papers by Sir Wm. Ramsay on the transmutation of copper into lithium and neon under the influence of radium emanation, and the controversy which gathered about them; and to the photographs, exhibited by Professor Dewar, of the apparatus used by Dr. Kamerlingh Onnes in the liquefaction of Helium.

Professor RUTHERFORD gave rapid summaries of a number of papers read before the Physical and Meteorological Section by Dr. Hale, Mr. W. Makower, Dr. Stansfield, and others. The work of Dr. Duffield on the influence of pressure on arc spectra was enlarged on, and the chief points in the discussion on the isothermal layer in the upper atmosphere were enumerated. The latter remarks gave rise to a further discussion on this interesting subject, in which Mr. C. E. Stromeyer, Mr. R. F. Gwyther, and others took part.

General Meeting, October 20th, 1908.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

Dr. MARTIN LIEBERT, Managing Director of Meister Lucius and Brüning Ltd., Manchester, *Swinton House, Withington*, was elected an ordinary member of the Society.

Ordinary Meeting, October 20th, 1908.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

Mr. D. M. S. WATSON, B.Sc., made some observations on a stone circle in the Orkney Islands, recently inspected by him, and explained what he believed to be the method by which the stones were originally placed in an upright position. He also stated that there was found in the rubble with which one of the stones was cemented into the ground, a stone implement with hollowed sides and rounded ends, the roughened surface of which pointed to its having been used as a mallet. The similarity of this to implements found in great numbers at Stonehenge seemed to indicate that the two circles were of approximately the same period, and dated from somewhere about 1400 B.C. or 1500 B.C.

Mr. C. GORDON HEWITT, M.Sc., F.E.S., exhibited and described a collection of fossil insects from Shiobara, Japan, collected there by Dr. Marie Stopes. These comprise a large number of the aquatic larvae of Ephemerids; examples of certain larvae and a single pupa of insects belonging to the dipterous family *Culicidae*; and representatives of a number of different families of Diptera, including one or two excellently preserved specimens of *Culicidae*.

The insects are preserved in a light grey laminated shale, and the fossiliferous deposit was evidently of fresh water origin, and appears to belong to the Tertiary age.

The collection, which is the property of the Manchester Museum, is one of very great interest, as no fossil insects from Japan have previously been described.

Mr. R. L. TAYLOR, F.C.S., F.I.C., gave some further notes on the Separation of Cobalt and Nickel. He referred to a former paper in which he had described a modification of Rose's method (barium or calcium carbonate in presence of chlorine or bromine). In that paper he had pointed out that various conditions caused a remarkable retardation in the precipitation of the cobalt. He now proposes the use of magnesium carbonate instead of calcium or barium carbonate, and finds that with this there is practically no uncertainty in the action.

Mr. H. BATEMAN, M.A., read a paper entitled "**On some Questions connected with the Constitution of the Atom.**" A portion of this paper is published in the *Memoirs* under the title "**A Method of Calculating the Number of Degrees of Freedom of a Molecule among which the Partition of Energy is governed by the Principal Temperature.**"

General Meeting, November 3rd, 1908.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

Mr. CHARLES FREDERICK SMITH, M.I.E.E., Lecturer in Electrical Engineering in the School of Technology, Manchester University; Mr. WILLIAM CRAMP, M.I.E.E., Consulting Engineer, 20, *Mount Street, Manchester*; Mr. J. A. REEKIE, Manager of the Hayfield Printworks, *Woodhouse, Hayfield*, were elected ordinary members of the Society.

Ordinary Meeting, November 3rd, 1908.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

Professor E. RUTHERFORD, F.R.S., read a paper entitled, "**The Nature of the « Particle**," written in conjunction with Mr. T. ROYDS, M.Sc. The paper is printed in the *Memoirs*.

Mr. T. ROYDS, M.Sc., read a paper written by Professor E. RUTHERFORD, F.R.S., and himself, entitled "**The Action of the Radium Emanation on Water.**" The paper was communicated by Professor RUTHERFORD, and the following is an abstract.

Experiments were made to repeat the experiments of Mr. Cameron and Sir William Ramsay, showing that neon is formed by the action of the radium emanation on water. Preliminary experiments showed that the neon present in $\frac{1}{15}$ cc. of atmospheric air could be detected spectroscopically while $\frac{1}{5}$ cc. of air gave a bright neon spectrum.

The general methods adopted were similar to those employed by Cameron and Ramsay. Pure emanation was condensed in a small glass flask containing water which had been initially completely freed from gases. After several days the mixed gases formed by the action of the emanation on the water were pumped out and examined for neon by the charcoal method. A number of experiments were made but, provided care was taken to prevent a leakage of air into the apparatus, no trace of neon was detected although the spectrum of helium was always clearly seen.

A number of experiments were also made to see if neon were present in the gases formed by the radium solution containing over 200 mgs. of radium, but none was observed, although a quantity of less than $\frac{1}{1000}$ c.cm. could have been

detected. Cameron and Ramsay do not appear to have been aware of the delicacy of the spectroscopic test for neon in air. They mention that it was difficult to avoid a leakage of air into their apparatus, and the amount of leakage in the experiment quoted in their paper is, in our experience, quite sufficient to give a bright spectrum of neon. Consequently, the experiment is quite inadequate to prove the production of neon by the emanation.

Professor E. RUTHERFORD, F.R.S., read a paper entitled, **"Some Properties of the Radium Emanation."** The paper is printed in the *Memoirs*.

In connection with the reading of the three above-mentioned papers, experiments were shown to illustrate the following phenomena :—

The fluorescence of a zinc sulphide screen, enclosed in an envelope, and of a crystal of willemite, under the action of the α particles of the emanation.

The rapidity of condensation of pure emanation contained in an exhausted vessel when one point was cooled to the temperature of liquid air.

General Meeting, November 17th, 1908,

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

Mr. ALFRED SCHWARTZ, A.K.C., M.Sc.Tech., M.I.E.E., Assoc.M.Inst.C.E., Professor of Electrical Engineering in the School of Technology, Manchester University, was elected an ordinary member of the Society.

Ordinary Meeting, November 17th, 1908.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

Mr. T. THORP exhibited and described a new form of spring he had devised and to which he had given the name "Twin-spring." The main characteristic of the spring is its extensive range and uniform force as compared with its length.

Mr. FRANCIS NICHOLSON, F.Z.S., M.B.O.U., read a paper, entitled "**Contributions to a Study of the Geographical Distribution of Birds. Pt. I.: The Genus *Macronyx*, Swainson.**" The paper is printed in full in the *Memoirs*.

Mr. A. H. GIBSON, M.Sc., read a paper, entitled "**On the Draught-inducing Properties of the Poker.**" The paper is printed in full in the *Memoirs* under the title "**On the Local Intensification of Draught produced in a Horizontal Air Current by the Presence of an Inclined Rod.**"

Mr. F. H. GRAVELY, M.Sc., read a paper, entitled "**Notes on the Spawning of *Eledone* and on the Occurrence of *Eledone* with the Suckers in Double Rows.**" The paper is printed in full in the *Memoirs*.

Ordinary Meeting, December 1st, 1908.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

The PRESIDENT referred to the death of Mr. R. D. Darbishire, who for many years took an active part in the proceedings of the Society. Mr. Darbishire joined the Society in 1853, served on the Council from 1869 to 1885, and was elected President in 1886. Mr. Darbishire's services to the Society, like his services to the community at large, were long-continued, disinterested, and carefully considered: but great as those services were, all who knew Mr. Darbishire were aware that his personality was even greater than his works.

The PRESIDENT also announced that Mr. H. Brereton Baker, M.A., D.Sc., F.R.S., Lee's Reader in Chemistry in the University of Oxford, would deliver the Wilde Lecture on March 9th, 1909, the subject being "The Influence of Moisture on the Combination of Gases."

Professor ALFRED SCHWARTZ, M.Sc. Tech., read a paper written in conjunction with Sir HUGH R. BEEVOR, Bart., M.D., entitled **"The Dawn of Human Intention: an Experimental and Comparative Study of Eoliths."** The paper will appear in full in the *Memoirs*.

The paper was profusely illustrated by lantern slides and drawings, and several hundred specimens, together with an experimental series, which members were invited to handle and examine for themselves, were exhibited.

An interesting discussion followed in which Professor W BOYD DAWKINS admired the ingenuity with which the authors of this paper had imitated some of the simpler primitive tools of man by experiment with flint splinters, and he thought it probable that these belonged to a very early stage in the evolution of culture because of their simplicity. They were found in Palaeolithic and Neolithic deposits, and had not yet been proved to occur in any strata before the Pleistocene age in any part of Europe. The term 'Eolithic' first used by Mr. Harrison, which includes these and numerous other broken flints probably not artificial, is based on the mistake that the sands and gravels of the Kent Plateau are pre-palaeolithic. They contain Palaeolithic haches of the usual type, as may be seen by reference to the British Museum, and, therefore, belong to that age. Professor Boyd Dawkins declined to accept any of the speculations based on this mistake, such as those put forward in the paper. The view that man lived on the earth during the Oligocene Period, a period before any of the living higher Mammalia had appeared on the earth is contrary to the law of evolution, and if 'Eolithic' flints do occur in these strata it is an argument against their artificial character. While not denying

that some Eoliths were the work of human hands, he looked upon them as belonging to the Palaeolithic Period, and criticised the classification of M. Rutot as an effort to push the first appearance of man on the earth to as early a period as possible, regardless of the evidence both biological and geological.

Ordinary Meeting, December 15th, 1908.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables. The following were among the recent accessions to the Society's Library:—"*Neue Untersuchungen über die Reifung und Befruchtung*," von F. Vejdovsky (fol., Prag, 1907) and "*Untersuchungen über die klimatischen Verhaltnisse von Beirut, Syrien*," von S. Kostlivý (4to., Prag, 1905), presented by the K. Böhmische Gesellschaft der Wissenschaften Prag; "*Report on a recent Discovery of Gold near Lake Megantic, Quebec*," by J. A. Dresser (8vo, Ottawa, 1908), "*Report on a portion of Conrad and Whitehorse mining districts, Yukon*," by D. D. Cairnes (8vo., Ottawa, 1908), "*Preliminary Report on a part of the Similkameen district, British Columbia*," by C. Camsell (8vo., Ottawa, 1907), and "*Preliminary Report on a portion of the Main Coast of British Columbia*," etc.,...by O. E. Leroy (8vo., Ottawa, 1908), presented by the Geological Survey of Canada; "*Sketch of the Mineral Resources of India*," by T. H. Holland (4to., Calcutta, 1908), presented by the Geological Survey of India, and "*A Monograph of the British Desmidiaceæ*," vol. 3, by W. and G. S. West (8vo., London, 1908), purchased from the Ray Society.

Mr. WALTER MAKOWER, B.A., B.Sc., read a paper entitled, "**The Volatility of Radium A and Radium C.**"

Mr. R. L. TAYLOR, F.C.S., F.I.C., read a paper entitled, "**On the Production of White Ferrous Ferrocyanide.**"

The papers will be printed in full in the *Memoirs*.

Manchester Memoirs, Vol. liii. (1909), *No.* 7.

VII. The Volatility of Radium A and Radium C.

By Walter Makower, B.A., B.Sc.

(*Received and read December 15th, 1908.*)

In the course of some experiments it was found necessary to know the temperature at which radium A volatilised, and as this had not previously been determined with accuracy, a series of experiments was carried out to determine the volatilisation point of this product. It was also considered of interest to redetermine the temperature of volatilisation of radium C under different conditions to see whether its volatility depended on its environment. The experiment on this point will be recorded after those relating to the volatility of radium A have been described and discussed.

The Volatility of Radium A.

The method used to determine the volatilisation point of radium A consisted in exposing a nickel rod to a known quantity of radium emanation for ten minutes at different temperatures, and examining the nature of the deposit so collected on the rod by observing the activity of the wire, measured by the α rays, and its rate of decay after removal from the emanation by means of a quadrant electrometer. Under these circumstances at ordinary temperatures there is a rapid decay of activity after removing the rod from the emanation for about fifteen minutes, after which the activity becomes constant for nearly half-an-hour, when it again begins to fall off slowly. As is well known, the initial rapid fall of activity

is due to the decay of radium A which has a time period of three minutes. If, therefore, radium A were in any way prevented from depositing on the rod, we should expect that not only would the activity of the rod after exposure to the emanation be much less, but on examining the deposit on the rod, the initial fall of activity should be entirely absent. These conditions would be fulfilled if the rod, exposed to the emanation, were kept above the volatilisation point of radium A; and, therefore, by examining the activity of a rod after exposure to the emanation at different temperatures, it should be possible to infer the volatilisation point of radium A by finding the temperature above which the product ceased to be deposited on the rod.

The apparatus used for carrying out the experiment is shown in *Fig.* 1, and was as follows. The nickel rod A,

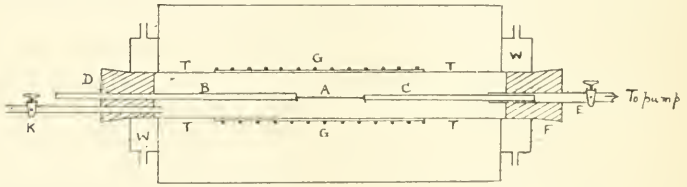


Fig. 1.

the activity of which was subsequently to be examined, was held in position along the axis of an iron tube T by the iron rods B and C, supported respectively in the rubber stopper D and the glass tube E which was itself held in position by the rubber stopper F. On the central portion of the tube T was wound a coil of nickel wire G, insulated from the tube by asbestos. The iron tube was contained in a larger porcelain tube P which was filled with kieselgur for heat insulation. By passing an electric

current through the coil G the central portion of the tube T, and therefore the rod A, could be brought to any desired temperature which was recorded by a platinum platinum-rhodium thermocouple situated near A (not shown in the figure). To prevent the rubber stoppers D and F from burning when the tube T was heated, water-coolers W were attached to ends of the tube T. The rod A was made so short, compared with the length of the iron tube, that its temperature was always sensibly uniform.

To make an experiment the tube T was heated to the required temperature and exhausted by a water pump. A known quantity of emanation was then admitted through the stop-cock K and the pressure adjusted to atmospheric.* After an exposure of ten minutes the rod A was removed and the α radiation coming from it tested in the usual way by a quadrant electrometer. The results obtained will be apparent from *Fig.* 2 in which the decay curves of the active deposit on the nickel rod at different temperatures are drawn.

The six curves given represent respectively the rate of decay of the activity collected on the nickel rod when maintained at 15° C., 710° C., 840° C., 885° C., 925° C., and 990° C. The first curve for 15° C. exhibits the usual characteristics of the α ray decay curves of the active deposit for a short time of exposure. The second curve shows the nature of the decay curve when the temperature of the rod is kept at 710° C. during the exposure to the emanation. It will be seen that the initial fall of activity due to the decay of radium A is still present, but the

* Previously to admitting into the iron tube, the emanation was exposed for about a minute to a strong electric field to remove any active deposit with which it might be associated. In this way the conditions of the experiments were rendered definite.

activity falls to a somewhat lower value before becoming constant than when the exposure is carried out at the temperature of the room. This is no doubt due to the fact that 710° C. is above the volatilisation point of

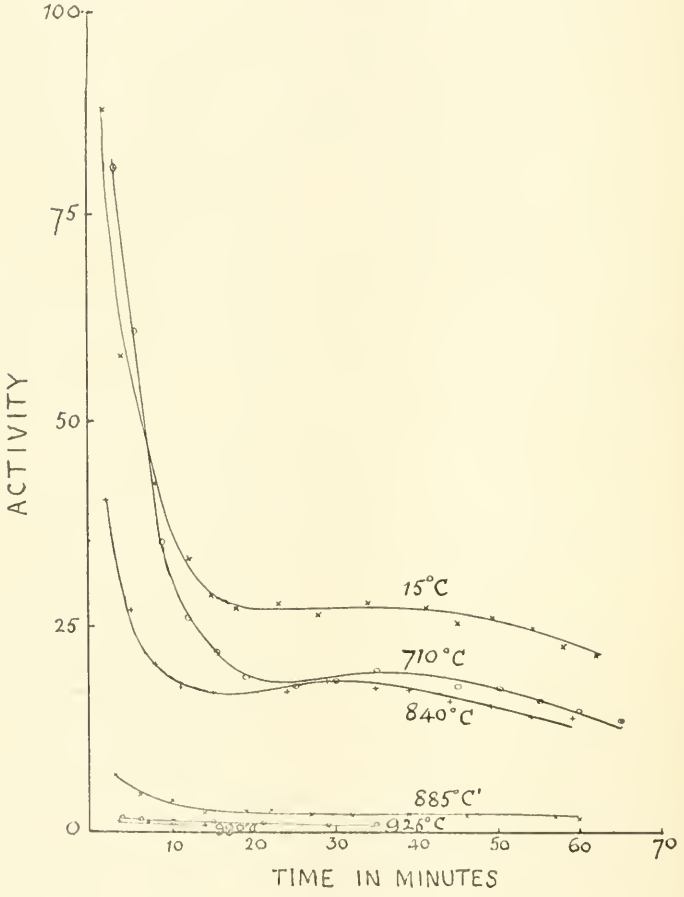


Fig. 2.

radium B, which cannot therefore be deposited on the rod. That the temperature of volatilisation of radium B is below 710° C. is further confirmed by the fact that above

this temperature the curves show a slight *increase* after the first rapid fall of activity, instead of merely becoming constant. This is what would be expected if the radium B were volatilised as soon as formed from the radium A deposited on the rod. This result is in agreement with the experiments of Curie and Daune,* who found for the volatilisation point of radium B the temperature 600° C. The 3rd, 4th, 5th, and 6th curves show the results obtained when the rod was exposed to the emanation at the higher temperatures. It will be noticed that already at 840° C. the initial drop of activity after removing from the emanation is less marked than at lower temperatures. At 885° C., the initial drop has almost disappeared, while at 925° C. there is practically no initial rapid drop of activity at all, showing that at this temperature no radium A was deposited on the rod. We may therefore infer that radium A begins to have an appreciable vapour pressure at 800° C., and that at 900° C. it is completely volatilised.

Volatility of Radium C.

The experiments on the volatility were undertaken not only to redetermine the volatilisation point with accuracy, but, as has already been mentioned, to investigate whether the environment of radium C had any influence on its volatility. The active deposit from radium was collected on plates of various materials by exposing them to radium emanation for several hours. After removal from the emanation and the lapse of sufficient time for the radium A to have decreased to an inappreciable amount, the material was subjected to any required temperature by inserting it in an electrically heated platinum-strip furnace for five minutes. The

* Curie and Daune, *Comptes Rendus*, 138, 1904.

presence of radium B did not constitute a disturbing factor in the experiments as this product is known to volatilise at a much lower temperature than radium C. Measurements of the activity before and after heating gave an estimate of the quantity of active deposit removed during the heating. The measurements were made with an α ray gold-leaf electroscope in the usual way. Care was always taken to blow through the furnace to obviate the possibility of any active deposit which had been volatilised and remained in the furnace from being redeposited. The results obtained with platinum, nickel, and quartz plates are shown in the table. It will be seen that in all cases the volatilisation begins between 700° and 800° C., but that whereas with platinum and nickel it is complete at 1200° C., the volatilisation of radium C on quartz surfaces is incomplete even at 1300° C. It thus appears that the volatility of radium C is to some extent dependent on the nature of the surface on which it is deposited, the volatilisation temperature being higher for a quartz than for a platinum or nickel surface.

It is well known that the active deposit from radium can be dissolved off a surface on which it has been deposited by hydrochloric acid. It seemed of interest to see whether the volatility of radium C was the same before and after solution or whether by the action of the acid this product had been chemically changed in such a manner as to be more or less volatile. Although a considerable number of experiments were carried out, no certain change in the volatility of radium C after solution in hydrochloric acid could be established. It always required, however, a somewhat higher temperature to completely remove the deposit from a quartz plate after solution in hydrochloric acid than from a platinum plate. This is in agreement with the observations mentioned above, with radium C

deposited directly on quartz and platinum and does not point to any direct action of the acid.

Activity before Heating = 100.					
Platinum Surface.		Nickel Surface.		Quartz Surface.	
Temperature Centigrade.	Activity after Heating.	Temperature Centigrade.	Activity after Heating.	Temperature Centigrade.	Activity after Heating.
750	90	760	96	900	83
980	56	980	71	1,130	40
1,090	32	1,110	25	1,200	33
1,140	19	1,200	1	1,250	27
1,200	4	—	—	1,320	15

Effect of an Electric Field on Radium C.

It is well known that when radium A is produced from the emanation under normal conditions it is charged with positive electricity. It thus happens that, when a negatively charged conductor is exposed to the emanation, nearly all the radium A produced is driven to the conductor, where it is deposited. It seemed of interest to find out whether radium C is similarly charged after its production from radium B.

Now we have seen that the volatilisation point of radium A is at 900° C., and the volatilisation point of radium B is lower. Since the volatilisation point of radium C is about 1,200° C., it would be impossible for either radium A or radium B to be deposited on a rod whose temperature was above 900° C., whereas radium C might, under suitable conditions, be deposited on the rod. In order to test whether radium C is charged at the moment of its

production from radium B, a platinum rod was exposed in the furnace described above (*Fig.* 1) at 950° C., and an electric field produced between the rod A and the iron tube T by connecting the rod D and the tube T respectively to the two terminals of a battery of 40 accumulators. The experiment showed that whether the rod A was charged positively or negatively with respect to the tube T, no appreciable amount of active deposit was collected on the rod A when subsequently tested in an electroscope. The experiment failed, therefore, to reveal any charge on radium C at the moment of its production, and it may be inferred that this product, unlike radium A, acquires no charge when it is formed from its predecessor in the radioactive series.

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Manchester Memoirs, Vol. liii. (1909), *No.* 8.

VIII. The Dawn of Human Intention. An Experimental and Comparative Study of Eoliths.

By Prof. Alfred Schwartz, Manchester,

and

Sir Hugh R. Beevor, Bart., M.D., London.

(*Read December 1st, 1908. Received for publication December 18th, 1908.*)

I. Introductory.

(1) In 1892, in a paper read before the Anthropological Institute, Harrison, Prestwich, and de Barri Crawshay, brought to the notice of the scientific world the Eoliths of the Kent Plateau. The views that they advanced have given rise to a great deal of controversy, and even after the lapse of 16 years the treatment of the question appears to be very largely a matter of individual opinion. At the present time there are a large number of persons who believe that Eoliths are the work of man, while an even larger number are convinced that they are the work of Nature. We hope to shew that the existence of Eoliths as the work of man is a fact which is capable of scientific demonstration.

(2) It will readily be admitted that the work undertaken by man in the earlier stages of his existence would be simpler and more general in character than in subsequent periods when specialised operations would be introduced as his culture advanced and his needs increased.

(3) This is actually the case, and we find the tools of the earliest man confined to the simplest types with which

they could perform operations of a general character. From pre-palæolithic time and throughout the lithic periods we find these original types persisting, supplemented later from time to time by specialised implements, such as arms, in accordance with the advancing needs of the communities.

(4) From anatomical and mechanical considerations, the fundamental processes in which primitive man would need the aid of tools may be summarised as follows:—

(1) Striking.
(2) Cutting.
(3) Scraping.
(4) Piercing.
(5) The production of fire.

(5) It is submitted that these operations were performed by the types of tools developed by pre-palæolithic man, and that these tools have persisted practically unaltered in character right through the age of stone, and that they have only ceased to be employed for the original purposes with the extinction of the Tasmanians in 1870.

(6) This view is due to Monsieur A. Rutot, of the Royal Museum of Natural History, Brussels, who, by his researches, has done so much to extend and explain the discoveries of Benjamin Harrison, and who has given to Eoliths their true place and significance in the history of mankind.

(7) In order to conform to this view the term "Eolithic," which, in the first instance, was applied to tools found in the chalk plateau in Kent and elsewhere, must now be extended so as to include not only the later industries with the same characteristics, but also the more ancient industries found in France and Belgium. It will perhaps then be convenient to consider the term "Eolithic" as a

generic one qualifying it with a second term to denote the chronological position of any given industry.*

(8) An Eolithic tool may be defined as one formed from a fragment of hard stone generally of siliceous material, which from its shape has been selected as suitable for the purpose in view, and which, when necessary, has been adapted for use by trimming. Such fragments may be purely natural, or may be obtained by shattering one stone against another, or by deliberate flaking.

(9) It is in connection with such trimmed fragments that utilisation by man can be first asserted.

(10) A Palæolithic or Neolithic tool, on the other hand, may be defined as one which has been intentionally fashioned and shaped to a specialised form.

(11) With Eoliths, therefore, we have the configuration of the tools almost entirely natural, the fragments selected having certain definite characteristics, and with Palæoliths and Neoliths the configuration is almost entirely artificial, and follows definite models.

(12) It is evident, therefore, that in judging whether Eoliths are or are not the work of man, the accepted criteria applied to Paleoliths and unground Neoliths, viz.: the bulb, cone, and conchoid of percussion, will not hold, as in the majority of cases the fragments from which the Eoliths were made were fractured naturally.

(13) It becomes necessary, therefore, to set up other criteria for Eoliths before we can assert definitely that they are the work of man, and we would submit that the following conditions with which an Eolithic implement should comply are efficient criteria :—

* It is proposed that this term shall be understood as meaning in a primary sense the form of the stone implements, with the purposes for which they were used in successive periods; and in a secondary sense the state of culture which is indicated by these implements.

(*a*) *Evidence of choice of material.* A selection and utilisation of a fragment of stone suitable and sufficient in shape and character as a tool for a specific class of work.

(*b*) *Evidence of wear.* Evidence of specific work performed, as shown by the conformability of the traces left upon the tool with those due to the class of work for which the tool was intended under (*a*).

(*c*) *Evidence of handling.* The adaptability of the tool for prehension and the dressing off of excrescences and the intentional blunting of certain sharp edges in conformity with the design of the tool as under (*a*).

(*d*) *Evidence of Sharpening.* The occurrence of secondary working or minor flaking on one side of the edge (for the purpose of giving a new edge to a blunt tool), identical in character with that found on accepted Palæolithic and Neolithic forms, and conformable with the design of the tool as under (*a*).

(*e*) *Evidence of association with allied types.* The presence in a given stratigraphical position of the principal fundamental classes of tool already referred to, in association with the tool under consideration.

(*f*) *Evidence from Prehistory and Anthropology.* The persistence of the type of tool throughout the stone age and its conformability with the type used by the most primitive tribes within the memory of man.

(14) It is not to be expected that every tool should satisfy the whole of the above conditions—for example, a hammer stone would not necessarily comply with (*c*), as

the natural crust of the stone in many cases needs no dressing for prehension, and it would not comply with (*d*), as it is not an edged tool, and would not therefore require re-sharpening, but it would show special marks of bruising from use.

(15) Apart, however, from some few special cases as instanced above, we take it that a rigorous compliance with the conditions specified would establish the fact that a given tool was the work of man, and not a natural production.

(16) As already stated, we hold that the Eolithic tools were originated and developed by pre-palæolithic man, and in consequence the various industries prior to Palæolithic times may be designated as purely Eolithic.

(17) The Palæolithic and Neolithic periods which are characterised by the presence of stone and bone implements intentionally shaped and fashioned for a definite and specialised, even if unknown, purpose, include also the Eolithic types, which were retained for general purposes.

(18) There is evidence, however, at many places in this country and on the continent, that in Neolithic times isolated communities existed, which remained as the Tasmanians did, entirely in the Eolithic culture stratum.

(19) Any industry which comprises only the original types of simple tools, without any admixture of intentionally shaped or ground tools, may be termed purely Eolithic.

II. Eolithic Types.

(20) In classifying the various forms of Eoliths, following Rutot, we have departed from the usual methods of classification according to shape, colour, locality, name of donor, etc., in favour of a classification based on the manner in which the tools were employed,

and in this connection we recognise the following classes of tools :—

(1) Striking.
(2) Pushing.
(3) Pulling.
(4) Rotating.

Each of these classes contains sub-divisions, which will be dealt with in detail.

(21) *Class I. Striking Tools.*

(*a*) Hammer stones.
(*b*) Chopping tools.
(*c*) Pick hammers.
(*d*) Anvils.
(*e*) Sharpeners.
(*f*) Fire stones.
(*g*) Throwing stones.

(22) *Class II. Pushing Tools.*

(*a*) Simple push-planes
(*b*) Double push-planes
(*c*) Convex push-planes
} For use on bone, wood, or hard material.

(*d*) Push scrapers or "Sleekers" — For use on skins or soft material.

(23) *Class III. Pulling Tools.*

(*a*) Simple scrapers.
(*b*) Double scrapers.
(*c*) Concave scrapers.
(*d*) Convex scrapers.
(*e*) Knives.
(*f*) Burins.

(24) *Class IV. Rotating Tools.*

(*a*) Borers.

(25) *Ia. Hammer Stones.* These consist usually of globular or cylindrical stones, one end or portion of which is adapted to be held in the palm of the hand, the other end in the case of flint or siliceous material presents a rugous surface formed by the juxtaposition of a number of little cones of percussion which are the product of the blows. (*Fig.* 1.)

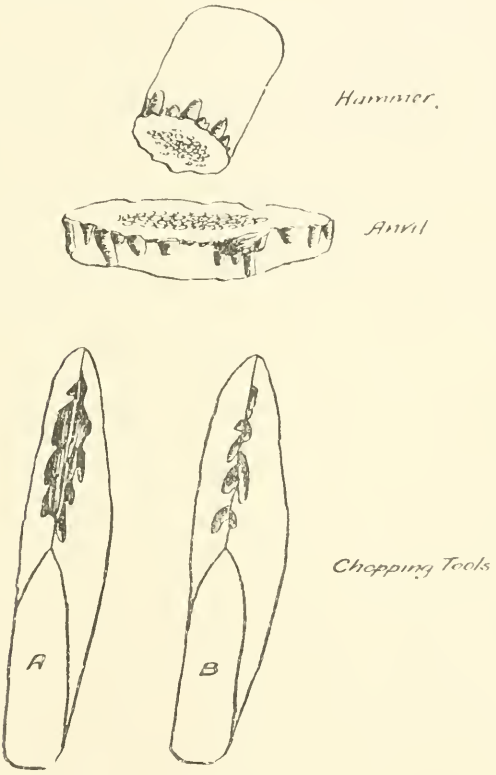

Fig. 1.

CHARACTERISTIC TRACES OF WORK ON STRIKING TOOLS.

When used for pounding soft material the faces on the hammer and anvil are marked with cones of percussion ; with hard material these are absent, but the edge flaking remains.

A. Crevassed or splintered effect of prolonged use of chopper with irregular flaking on both sides of the cutting edge.

B. Light chopping work gives only the irregular flaking.

(26) The striking end is also frequently surrounded by an aureole of chips which have flaked off its periphery where it has come into sufficiently violent contact with the anvil. This condition is produced by pounding soft material, as roots on a flint anvil; the material being easily crushed allows the hammer and the anvil to come into frequent contact. In this case the anvil presents similar characteristics to the hammer, namely, a rugous surface and edge flaking.

(27) If the object to be broken or crushed is a hard one such as bone, the characteristic traces of the work are somewhat different in that the cones of percussion are absent, or very much reduced in number, the edge flaking is also frequently not so bold. This is due to the shock of the blow being received on the hard material, and being transmitted to a sufficiently large area of the anvil to prevent the formation of cones of percussion. The material to be crushed—particularly in the case of long bones—usually takes a localised bearing on the edge of the anvil, and transmits to it sufficient force to produce edge flaking. For the same reason the cones of percussion are in this case absent from the hammer, and the edge flaking is present in a modified degree as in the anvil.

(28) *Ib. Chopping Tools.* There are two varieties of chopping tool, the first or longitudinal type consisting of a natural or artificial fragment of elongated form and wedge shape in cross section. The thick edge is held in the palm of the hand edge down, the arm working as with a hatchet. This is the "percuteur à tranchant longitudinal" or "Tranchoir" of Rutot.

(29) The second variety is the transverse chopping tool, and is formed from a fragment in the shape of a trapeze considerably elongated in the direction of its

height, the broad end bearing the cutting edge. This implement is the "Tranchet" or "percuteur à tranchant transversal" of Rutot, and is gripped between the fingers and the palm of the hand, with the cutting edge downwards, the tool working as an adze.

(30) The characteristic traces of the work found on chopping tools take the form of a number of flakes irregularly displaced from the cutting edge. Owing to the fact that the object to be cut is usually placed opposite the median line of the body, and that the blows are delivered a little from one side, it will be found that a larger number of flakes are detached from one side of the choppers than from the other. (*Fig.* 1B.)

(31) From the relative sizes of these two types of chopper, it would appear that the longitudinal variety, which is the larger, was employed for the coarser kinds of work, while the lighter transverse type was reserved for less severe service.

(32) As regards the dressing for holding the tool, with the longitudinal type, it is usually confined to the removal of inconvenient excrescences, and the blunting of the edges of the thick end, while in the transverse type, which is grasped in the hand, more careful dressing is required to prevent the fingers and the palm of the hand from being wounded.

(33) If the action of chopping, as of pounding, be continued for some time, the cones of percussion formed, and the flakes detached from the chopper become so numerous and intersect so frequently that the surface material breaks away in splinters giving rise to what may be termed a "crevassed" appearance, which is characteristic of these modes of striking. (*Fig.* 1A.)

(34) *Ic. Pick Hammers.* This type is simply the common elongated nodule, one or both ends of which are

used for striking. The characteristic traces of the work are some degree of those named for hammer stones, namely an aureole of flakes around the striking end. L-shaped stones are also employed, one branch being held in the hand.

(35) *Id. Anvils.* The anvil may be regarded as a passive hammer, and as already pointed out under *1a* p. 8, the characteristic traces of the work are the same as for hammer stones; in addition to those traces, in some instances the battering of the underside of the anvil against the stones upon which it rests may be observed.

(36) The fragments selected for anvils vary considerably in size, some being quite small. One surface is usually flat and frequently the surface opposed to this is flat also, and in such cases both faces are often used for striking on.

(37) As would be expected, the blows received on the anvil would vary considerably in intensity, and in consequence the flakes detached are of all sizes from small to large, disposed in an irregular manner along the edges, but all running in the same direction, that is from the face to the base.

(38) *Ie. Sharpeners.* These are specialised forms of hammers employed for producing the secondary working necessary for re-sharpening a blunt tool. In form they are elongated prisms, and on one edge show battering due to percussion of a light character.

(39) *If. Fire Stones.* Throughout the lithic industries there occur fragments of stone bearing manifest traces of flaking which in the present state of our ignorance it is difficult to assign to a definite class of tool. They show along their edges the effects of a series of blows distributed in groups. The flaking, while it is in the same direction for a given group, is frequently in reverse directions for

different groups. In form they simulate anvils or even planes, but they differ from these in the coarseness of the flaking, and in the presence of the crust of the flint on the face from the plane of which the blows were struck, which at once disposes of the notion that these implements could have been used for cutting purposes. In 1874, Lartet and Christy* suggested that similar Moustier specimens were used in the production of fire, and stated that fire was obtainable not only by the friction of pyrites and flint, but also from two flints, and that in Norfolk and Suffolk less than 100 years ago fire was obtained in this manner, by striking two flints rapidly against one another in the presence of dry moss.

(40) This method is apparently practiced by certain primitive tribes; on Bathurst Island the Australian† aborigines were seen with two pieces of white flint and a tinder of the inner bark of the papyrus.

(41) With reference to the use of such fire stones by the Tasmanians, Furneaux‡ reports to have found in one of the huts, "the stone they strike fire with and tinder made of bark, but of what tree could not be distinguished."

(42) La Billardière§ states that in Tasmania he "met with pieces of flint (sic) and fragments of the bark of a tree as soft as the best tinder," and that "these savages undoubtedly produced fire by striking two pieces of flint together."

(43) Lieutenant G. Mortimer‖ states that in some of

* "Reliquiae Aquitanicae," pp. 85, 86, 138—140.

† "The Daily Life of the Tasmanians." J. Bonwick, London, 1870, p. 21.

‡ Cook's Second Voyage, Book I, Chapter VIII.

§ "An account of a voyage in search of la Perouse." J. J. de la Billardière, London, 1800.

‖ "Observations and remarks made during a voyage to the Islands of Teneriffe, etc." G. Mortimer, London, 1791.

the Tasmanian baskets "were a few flints and stones and a little dried grass, from which circumstances I conclude they produce fire by collision."

(44) *Ig. Throwing Stones.* These, if this be the nature of their use, are of a somewhat indeterminate character in that they bear no special traces of dressing for prehension or of the work performed. Their general characteristics may be stated as consisting of a polyhedral form, made up of natural and artificially chipped faces irregularly distributed, which present a number of cutttng edges and points; the size is such as to be suitable for throwing.

(45) *Class II. Pushing Tools.* These consist of a fragment of stone held between the thumb and index finger, the cutting edge being at the end away from the operator. Their special characteristics consist of a plane surface under the cutting edge or edges, the dressing for prehension which consists in the blunting of the edges at the sides, and in many instances in the formation of distinct notches for the fingers and thumb.

(46) These notches must be carefully distinguished from the notches so frequently formed on the working edge of the tool due to re-sharpening, for the reason given later in the section dealing with sharpening.

(47) The various forms of push plane are shewn diagrammatically in *Fig.* 2. In each case the cutting edge is shewn with a double line, and the usual positions for the dressing for prehension with a broken line.

(48) Each of these various designs has its obvious advantages for certain classes of work, but it must be understood that the diagram is intended to represent the initial forms of the implements, and that after being re-sharpened several times these forms would be somewhat modified. For instance, the rectilinear form would after

re-sharpening sometimes simulate the concave form, although a close inspection will allow of their being differentiated. In all cases re-sharpening tends to produce irregularity of outline which continued work tends to smooth down.

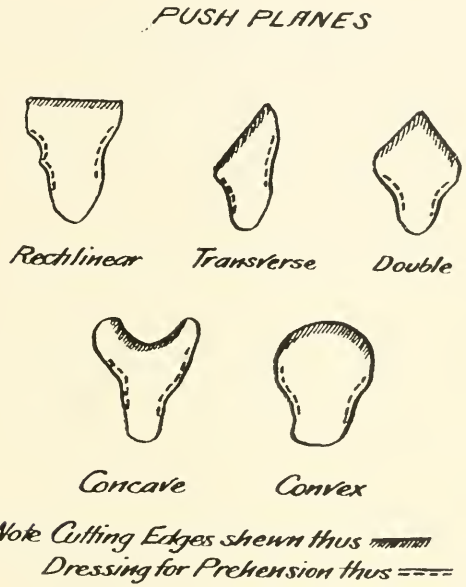

Fig. 2.

(49) The push planes were probably actuated in a downward direction, the surface to be worked upon being more or less vertical.

(50) *Class III. Scrapers.* These implements are usually formed from natural fragments or struck flakes oval or D-shaped in form and wedge-shaped in cross section. The thick edge is held in the palm of the hand with the index finger extended along it, the thumb being placed on the face nearest to the operator, and the remaining fingers on the far side of the tool, while the cutting

edge, which is parallel to the axis of the forearm, rests perpendicularly upon the surface of the work.

(51) In order to realise exactly the mode of operation of this class of tool, it is necessary to consider the behaviour of a thin flint edge when actuatedin various ways.

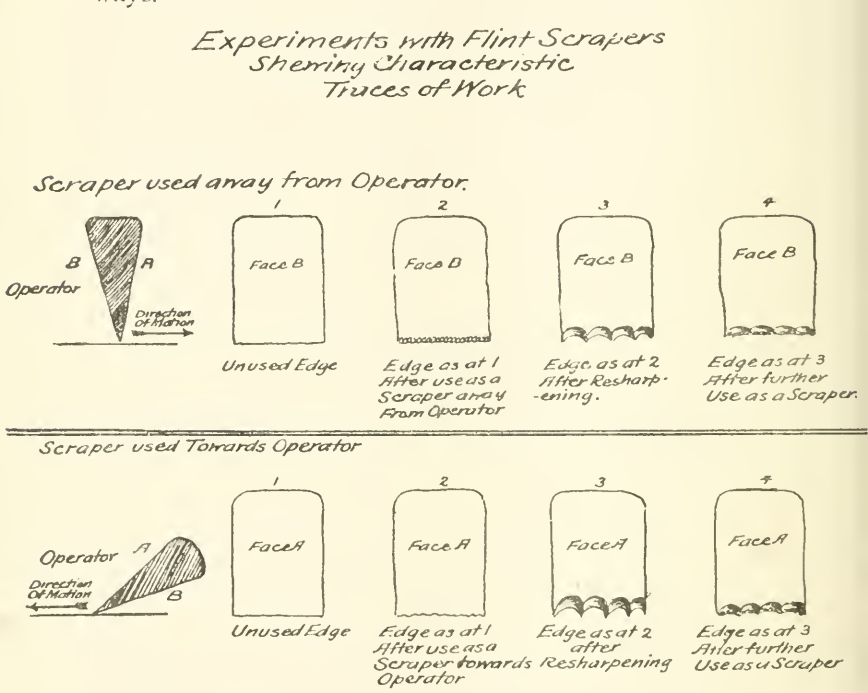

Fig. 3.

(52) When such an edge is posed perpendicularly to the work and pulled under pressure towards the operator, a regular line of minute flakes is formed on the side of the edge away from the operator.

(53) The tool should be used in one direction only, and after the edge has become dulled, it can be re-sharpened by striking with another stone from the side of the tool which faces the operator when in use, a series of

small contiguous flakes. These flakes will replace the series of minute flakes produced by the work. On re-suming the work after re-sharpening, it will be found that the splintering of the edge continues, and tends to reduce the irregular outline due to the re-sharpening. These effects are shown diagrammatically in *Fig.* 3.

(54) A consideration of this figure will show that by turning the implement and reversing the positions of the faces A and B relatively to the operator and changing the pulling motion into a pushing one, the effects of the work on the flint edge would not be altered.

(55) The "Racloirs" of Rutot are in his view used in this way, but this method of working is open to criticism on anatomical grounds, as the human arm is not capable of exerting so much force in a push as in a pull, and it is submitted that the most effective movement of the fore-arm is towards the body. Its great strength and facility in this direction has no doubt been induced from the necessity of conveying food to the mouth.

There are, however, certain classes of work, such as the dressing of skins, in which the motion away from the operator is advantageous. In the Blackmore Museum, Salisbury, there is a stone scraper used by the S. American Indians of the Amazon district in this way, the operator squatting or kneeling with the skin to be scraped stretched across the thigh of one leg.

(56) There is, however, a further alternative; if the tool, instead of being posed with its cutting edge perpendicular to the surface to be worked upon, be held with the cutting edge towards the operator, and at angles up to about 40° from the horizontal, it will work quite well as a pull tool, indeed in its initial state a great deal more work can be done with a tool used in this way than in either of the preceding fashions. The lower portion of

Fig. 3 shows the arrangement, and the effects of the work both before and after re-sharpening.

(57) The various types of scrapers are shewn diagrammatically in *Fig.* 4.

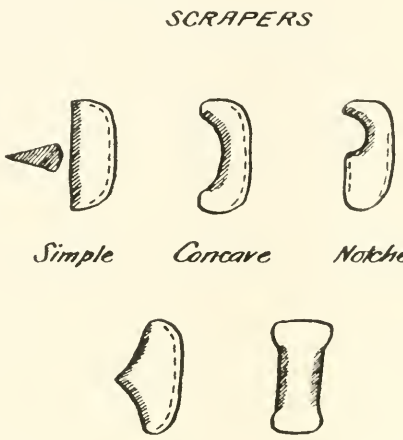

Fig. 4.

(58) It will be noted that knives are classed among the instruments which are pulled. This classification is based on anatomical considerations, and on the fact that the Tasmanians have been observed using their stone knives in this fashion. This they did by extending the arm with the index finger pressed upon the knife at a point furthest from the operator, and then drawing the implement rapidly towards them.

(59) These tools are usually triangular in cross section, thus giving a thin cutting edge, the thick back affording a resting place for the index finger, and giving strength to the tool.

(60) The characteristic trace of the work of cutting may be found in the irregular displacement of a number of fine chips on both sides of the cutting edge. In addition to the ordinary dressing for prehension, a special dressing at the end of the knife is frequently found for the extended index.

(61) *Class IIIf. Burins.* Under this head we class points with cutting edges which might be used by being drawn towards the operator in forming grooves in the handles of clubs, or cutting out narrow strips of bone for needles, etc., from long shank bones.

(62) *Class IV. Rotating Tools.* In the majority of instances these tools have not been deliberately shaped out, but have been formed from natural pointed fragments, or such fragments produced by shattering one stone on another. These points are adapted and dressed into shape when necessary by means of a Re-sharpener.

(63) If the hole be shallow, the tool would only be rotated to and fro through an angle of 90°. If, however, it be deep enough to support the tool, the latter could be completely rotated.

(64) The characteristic traces of the work in the case of demi-rotation consist in the removal of small splinters from both sides of the cutting edges. In the case of complete rotation, this is observable only on one side of the edges, and may have given rise to the "reversed work" referred to above. It is interesting to note that this form is still adhered to in modern solid steel drills. (See *Fig.* 5.)

(65) With piercers which have been dressed into shape by the sharpener, less trace of the work is found than with natural borers.

III. RE-SHARPENING.

(66) The method of re-sharpening a blunt tool by striking off from one side of the cutting edge with another stone a series of small contiguous flakes, has already been referred to. This method is applied only to push-planes and scrapers ; knives were not re-sharpened, as the knife edge could not thus be reproduced.

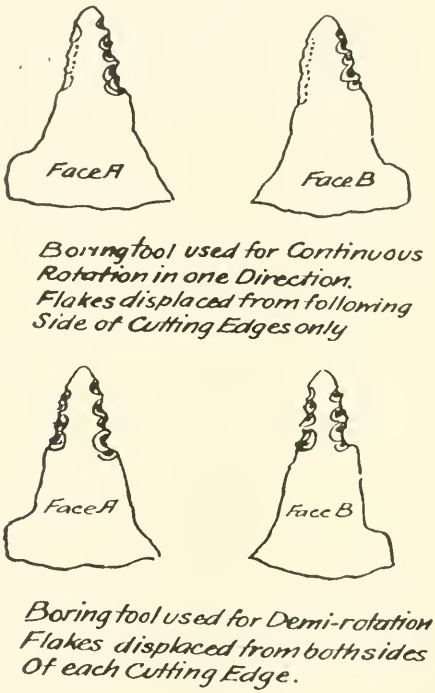
Face A
Face B
Boring tool used for Continuous Rotation in one Direction. Flakes displaced from following Side of Cutting Edges only
Face A
Face B
Boring tool used for Demi-rotation Flakes displaced from both sides Of each Cutting Edge.

Fig. 5.

CHARACTERISTIC TRACES OF WORK ON BORING TOOLS.

(67) A series of fine minor flakes can also be got by pressure. This may be done by holding the cutting edge at an angle approaching a right angle to a hard smooth surface, and drawing it under pressure either to

or away from the operator, in which case a series of small flakes will be detached from the face opposite to the direction of motion. This on a thin edge is tantamount to re-sharpening, but it cannot be used on an edge with a high cutting angle.

(68) This effect can also be produced on a thin flint edge by placing the flake flat on a smooth surface, and drawing a knife blade, or a suitably shaped stone, along the upper side of the edge under a moderate and even downward pressure.

(69) A fresh flint edge will serve for about 5 to 10 minutes when working on bone. This time will, of course, vary with the vigour with which the work is carried out, and with the nature of the material operated upon, but it is of the order named.

(70) After being re-sharpened once, the edge will not be found to serve for so long a time as in the first instance, and the length of time of efficient service diminishes with each subsequent re-sharpening. This is due to the fact that the cutting edge is brought nearer to the body of the tool with each operation of re-sharpening, and the angle of the cutting edge becomes correspondingly less acute. (*Fig.* 6.) This factor limits the number of times a tool may be re-sharpened to three or four at the utmost, the cutting edge will then have been worked back to a position where its angle will be a right angle, and where the increased thickness of the tool renders it impossible to detach small flakes, the blows from the sharpener merely shattering the edge without dislodging flakes. In this condition the tool must be discarded, as it is useless for further work.

(71) The effects of secondary flaking for re-sharpening are cumulative, and the number of times the tool has been re-sharpened before being rejected may consequently

be recognised. A tool rejected without having been re-sharpened may be said to be in the "first state," after being re-sharpened once in the "second state," and so on. Eolithic tools may then be found which have been discarded after use without being re-sharpened, or after having been re-sharpened once, twice, or thrice.

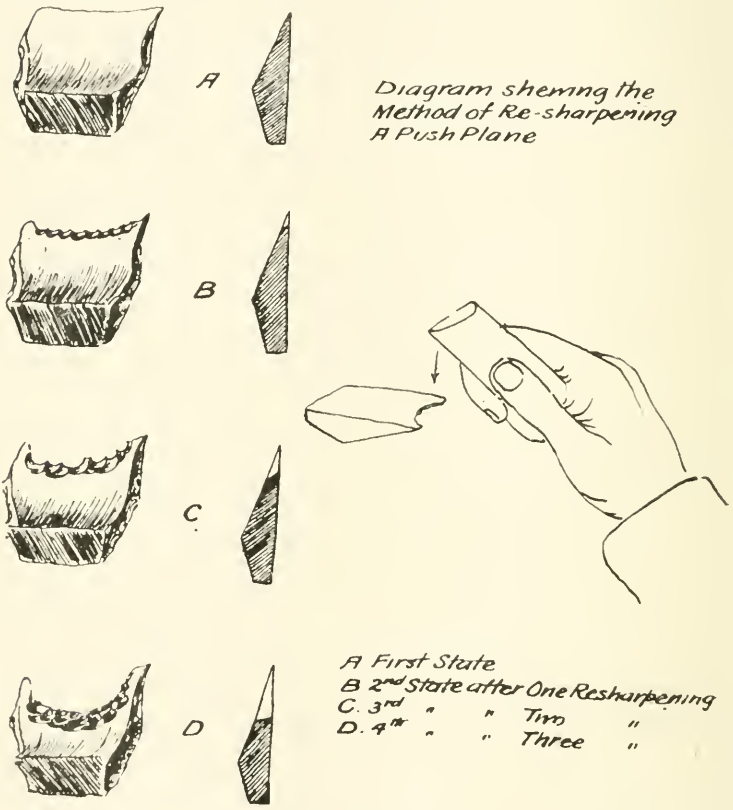

Fig. 6.

(72) Implements which are frequently referred to as being "fine specimens" are those in which the re-sharpening has been pushed to the maximum extent possible, and such are the less efficient tools having in

reality been discarded as useless for further work. The amount of re-sharpening to which the tools of a given industry were subjected, depended to some extent on the abundance or scarcity of natural fragments of suitable character, or of the quantity of material available from which suitable flakes could be struck. Where flint was scarce, the tools are found to have been re-sharpened as much as possible before being discarded.

(73) One of the objections urged against the authenticity of Eoliths is the large numbers in which they are found, compared with Palæoliths. We should, however, expect that tools which were used for general purposes, and which could be fabricated in a few minutes from natural fragments, and which sufficed at the most for less than half-an-hour's work, would be much more numerous than the Palæolithic implements which were designed and reserved for special uses.

IV. Chronological Sequence of the Eolithic Industries.

(74) The sequence of the purely Eolithic Industries and their relationship to the Palæolithic and Neolithic groups, according to Mons. Rutot's classification, are given in Table I.

Table I.

Classification of the Lithic Industries, by M. A. Rutot.

Note.—The purely Eolithic industries are shown in italics.

TERTIARY.

Period.		*Industry.*
Oligocene	Lower	
	Middle	*Fagnien* (Hautes Fagnes, Belgium).
	Upper	
Miocene	Lower	
	Middle	
	Upper	*Cantalien* (Cantal, France).

Pliocene { Lower / Middle ..... *Kentien* (Chalk Plateau, Kent). / Upper ..... *St. Prestien* (St. Prest., France).

QUATERNARY.

Eolithic — *Reutélien* (Reutél Elouges Hainaut, Belgium).
Mafflien (Maffle. Salzinnes Hainaut, Belgium).
Mesvinien ("Exploitation Helin," Spiennes Haine Valley, Belgium).

Lower Palæolithic (Drift) — Strépyien (Strépy, Haine Valley, Belgium).
Chelléen (St. Acheul, France).
Acheuléen I. (Ditto).
Acheuléen II. (Ditto).

Upper Palæolithic (Caves) — Moustérien (Vezere, France).

Aurignacien { Lower / Middle / Upper } (Vezère, France).

Solutréen ... { Lower (Solutré, France). / Upper (Laugerie Haute, Vezère, France).

Magdalénien { Lower / Middle / Upper } La Madeleine, France.

Neolithic ..... Tardenoisien (Aisne, France).
Flenúsien (Flenu, Belgium).
Campignyien (Campigny, France).

Period of Polished Stone. { Spiennien (Spiennes, Belgium). / Scandinavian { Omalien (Omal, Belgium). / Megalithic (Bretagne, France), Scandinavia.

Note.—The Neolithic classification is not yet definitely settled.

(75) The following brief notes are explanatory of Rutot's views of the character and position of the various Eolithic industries referred to in Table I. The Palæolithic

industries are not referred to, but it must be understood that the Eolithic tools persisted through these periods for general purposes.

The Fagnien. The implements of this industry were discovered at Boncelles, near Liège, Belgium, at an altitude of 860 feet above sea level, and 600 feet above the level of the River Ourthe. The Eoliths were found in the clay and flints at the base of the deposits of the upper Oligocene containing *Cytherea Beyrichi, Pectunculus obovatus*, etc.

The Cantalien. This industry is that of Puy Courny. A considerable number of implements have a bulb of percussion.

The Kentien. This industry is represented in Harrison's pits in the Kent Plateau gravel at an altitude of about 700 feet above the sea level. It is also found in the thin spreads of Ochreous gravels on the chalk plateau. It has also been found by Dr. H. P. Blackmore in the deposits of the "high terrace" at Laverstock, near Salisbury, and by the Rev. H. G. O. Kendall on Hackpen Hill, near Marlborough.* The surface of the Kent Plateau also yields numerous specimens of Eoliths of the Flenusien division of the Neolithic period. These can be readily distinguished from the Kentien specimens by their patina, and from the fact that they are unrolled. Owing to their being rolled to a considerable extent, the Kentien Eoliths are among the most difficult to make out, and it is no doubt due to this fact that acceptance of Eoliths in this country has made such slow progress.

St. Prestien. The Eoliths at St. Prest are associated with *Elephas meridionalis.* They are found at the base of the deposits of the middle terrace of the river valleys at altitudes of between 100 and 200 feet above the present

* *Proc. Geol. Assoc.*, vol. 20, p. 7, 1908.

river levels. Dr. H. P. Blackmore has found these Eoliths in association with *Elephas meridionalis* at Dewlish. Mr. Lewis Abbott has also found Eoliths of this period in the Cromer beds.

The Reutélien is the oldest quaternary Eolithic Industry. The implements are found on the top of the gravel deposits at the base of the middle terrace, and it is well represented in the neighbourhood of Salisbury, especially at Alderbury.

The Mafflien industry is met with at the base of the lower quaternary deposits of the low terraces of the valleys of the Franco-Belgian basin. It does not differ much in character from the Reutélian. It is represented at Erith.

The Mesvinien industry is found in the gravels at the top of the lower quaternary deposits. Many of the implements bear the bulb of percussion, and the development of intentional flaking belongs to this period. A mixture of Mafflien and Mesvinien implements may be found in the low terrace deposits of most of our large rivers.

The Strépyien industry represents the transition between the Eolithic and Palæolithic cultures. It is characterised by an admixture of Eolithic forms and rude implements intentionally shaped and intended for specialised uses. It is well represented at Rickmansworth. Many of the implements bear the bulb of percussion. After the Strépyien came the Chelléen and the Acheuléen and the Upper Palæolithic industry from the caves.

(76) The Neolithic division is complex and varies with locality, in Central Europe there appear to be five or six divisions. The Tardenoisien ("Pigmy" tools) the Flenusien and the Campignyien contain no polished implements. The Flenusien is a purely Eolithic industry,

and is well represented by the surface finds on the chalk plateau of Kent and Surrey, which resemble in a remarkable degree the Flenusien implements found at Grace Berleur, near Liège, and in the Hesbaye, near Avennes. The Campignyien industry or Scandinavian Kjökkenmödinger industry followed on the Flenusien, and with it the intentional shaping of tools re-appears, some of the push planes having a regular convex edge. The

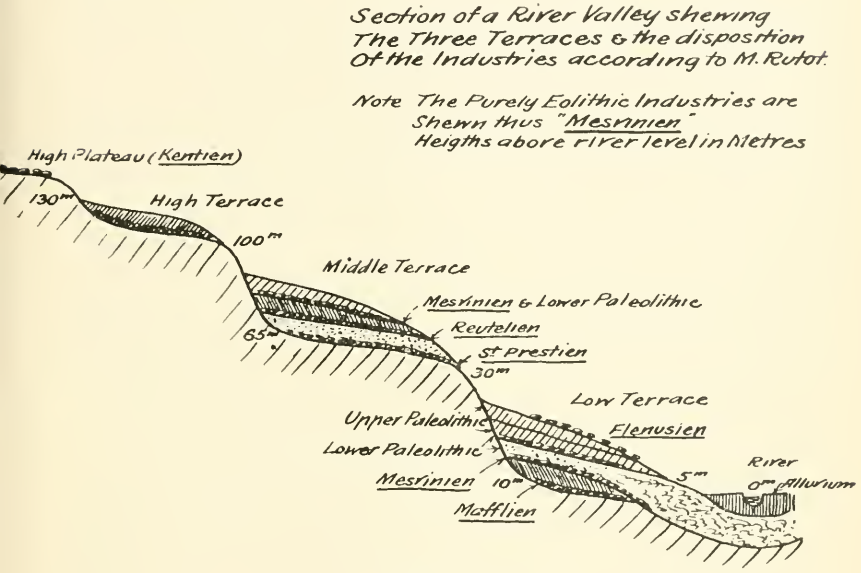

Fig. 7.

Campignyien peoples in France, Belgium, and this country were very partial to the black flint from the chalk, and most of their implements bear the bulb of percussion. They are well represented in the valley of the Axe and on the hills at the mouth of the river, and also on the surface of the Kent plateau and elsewhere.

(77) The sequence of the industries and their relative positions with regard to the river terraces are well shewn in *Fig.* 7 (Rutot).

V. THE "BULBED" EOLITHS OF CROXLEY.

(78) In this section the term "Eolith" is used in the connotation to express a tool of pre-palæolithic type, for the industry at Croxley cannot be considered as purely Eolithic, as it belongs to the "Strepyien" or transition period from the Eolithic to the Palæolithic cultures.

(79) With reference to the geology of the Croxley Long Valley gravel pits, up to the present time the remains of animals found are few. Sir John Evans recorded *Elephas antiquus* and *Cervus elephus*, and Prof. Seeley has identified *Equus fossilis* and *Bos.* (?)

(80) The elevation of the chalk floor of this pit is 200 feet O. D., being 40 feet above the level of the river "Gade" which skirts it. The gravel is moulded upon an irregular chalk surface, differences of level of as much as 15 feet being obtained within a few yards. Hummocks of Woolwich and Reading beds were left upon the chalk, sometimes with layers of black ovate pebbles, sometimes of yellow, white, or greenish sands, with botryoidal sarsen stone concretions occasionally several feet in diameter.

(81) Above the floor a section shows about 20 feet of sands with marked false bedding, containing pebbles and cracked flints in varying proportion at different levels. As a rule there is no loam in this sand, and even in the least pebbly part a big flint, looking fresh from the chalk, may occur.

(82) A narrow band of black gravel occurs, but not persistently, in the middle and upper part of the section, and at 20 feet from the chalk is a layer of clay, 2 feet in thickness, which from its colour shows itself to be a relaid remnant of the London clay, which has been denuded from the upper levels of nearly all the adjacent country; this contains a few white flints, and is here and there crumpled by dislocation from subsidences. Above this

lies 6 feet of loamy or clayey "Plateau" gravel, which extends for miles over this country.

(83) Compared with other pits in the valley there are several peculiarities to be noted :—

(1) Its very sandy character, whereas loam is the usual matrix.

(2) The numerous pipes—some even 20 yards in diameter, of brown loam, or nearly pure brick earth.

(3) The chalk over much of the base of the pit is relaid to the extent sometimes of 2 or 3 feet. with yellow pebbles scattered in it.

(4) In some parts a large proportion of the flints are cracked, but frost pitted flints are seldom found.

(84) Some hundreds of tons of gravel have been moved daily and have yielded in the past two years about 200 Palæolithic implements. In type they closely resemble those of St. Acheul. The large and very rude Palæoliths of the Chelléen type are also represented.

(85) Far more numerous than Palæoliths are these Eoliths ; the workmen sifting the gravel roughly at the lowest levels where the Eoliths are most numerous will pick out about five to the cubic yard, most with the bulb of percussion. They are quite unrolled, and rarely scratched. The presumption accordingly is that we are close to the habitat of their owners, except in the case of the quite occasional much rolled Palæolith or Eolith.

(86) A collection of several hundred specimens fell readily and almost completely into the various divisions of the classification already referred to. The bulbed flakes fell at once into one of the three categories of scrapers, push planes, and knives ; occasionally a drill, anvil, or hammer might be found with the bulb, and but

a very small remnant seemed to be the unutilized bye-product of manufacture.

(87) Very rarely do these Eolithic tools show bilateral symmetry, the majority have a considerable amount of the original crust of the flint from which they were struck left upon them. As to dimensions they are thick, and generally as broad as they are long. These features, though not precise for individual specimens, are very distinctive when one looks at a collection, and similar tools from the surface of the soil referred to below are apt to run in a series of rather different proportions.

(88) When a good tool is found—in this pit at all events—with the special characteristics of its class but without the bulb of percussion, the presumption must be that it is man's design, and not due to a chapter of accidents.

(89) On the surface of the soil in the Croxley district, bulbed tools of somewhat similar form to the above are found in considerable numbers. They are never ochreous in colour, and are manifestly not derived from the underlying gravel, and an inspection of a pit being worked close at hand yielded no specimens.

(90) These surface bulbed flakes admit of a classification corresponding to that which has been given for the tools from the gravel. The same dressing for handling and the same chipping for re-sharpening re-appear.

(91) No collection of them was made until a few months back, and accordingly the exhibit here made is the result of but a very meagre search over the ploughlands of the neighbourhood, about 100 specimens being collected at three sites of from one or two acres.

(92) Of the tools, knives have not presented themselves in any number, and such as have been found are cruder than the usual long Neolithic knife flake, and

resemble more the knives from the gravel. The larger tools one is not surprised to pick up but seldom, as they are likely to have been removed from the fields.

VI. Eolithic Chipping.

(93) Mr. S. Hazeldine Warren, in an able paper on the origin of Eolithic flints by natural causes* suggests the following possible means by which Eoliths may have been formed :—

(1) Human agency.
(2) Water abrasion by wave action.
(3) Water abrasion by streams, rivers, and floods.
(4) Soil abrasion by the pressure and movement of soil creep and foundering.
(5) The drag of ice.
(6) Wear and tear on the surface of the ground.

(94) Of these, the Human agency is the only one that is applicable to all the situations in which Eoliths have been found, the five remaining agents have to be invoked in turn to account for chipping, which has a common character independent of the location of the implements.

(95) We are prepared to admit that some of the agents referred to may, under certain circumstances, produce flaking effects, which simulate those found on Eoliths, but in considering the flaking produced by any given agent, we must also consider its concomitants. Thus, in the case of wave action, it has been shown by Hahne and Rutot† that the Pseudo-Eoliths produced under particular conditions at a certain part of the coast of the Island of Ruegen are ephemeral. After being exposed for a short time to the grinding action of large

* *Journal of the Anthropological Institute*, vol. 35, 1905.

† "Éolithes et Pseudo-Éolithes." Communication by A. Rutot to the Société d'Anthropologie de Bruxelles, Jan., 1906.

rounded blocks which are moved by the waves, certain forms are produced which simulate Eoliths, but a further exposure to this action speedily destroyed them.

(96) The same effect follows in streams, the action in this case being one of abrasion rather than disintegration. Stream action on Palæoliths as well as on Eolithic forms associated with them is one of rounding of edges rather than of flaking. MM. de Munck and Ghilain* have independently carefully investigated the action of rapid streams fed with angular fragments of flint and with true Eoliths which were contained in the beds, through which the upper reaches of the river ran.

Specimens from the river bed were taken from various points down the stream, with the result that in a distance of from 1 to 2 miles, the angular flints and Eoliths had been transformed into rounded pebbles. Specimens from the intermediate points shewed that the action was one of abrasion and not of chipping.

(97) The experiments of MM. Boule† and Obermaier with wash mills fitted with iron harrows cannot be considered as having been carried out under conditions comparable with those obtaining in natural streams. F. J. Bennett‡ found that in the Kentish wash mills the flints which had been in the mill a considerable time and were out of the reach of the iron harrows were almost perfectly smooth spheres.

(98) Striation and 'ladder fracture' are concomitants of ice action, and Eoliths subjected to this agent are easily recognisable.

* Congrès prehistorique de France, Autun, 1907. "La fin de la question des Éoliths," A. Rutot.

† "L'origine des Éoliths," Marcelin Boule, *L'Anthropologie*, vol. 16, March-April, 1905.

‡ *Geological Magazine*, 1906, Decade v., iii, 69-72, 143-4.

(99) Soil abrasion by the pressure and movement due to soil creep and foundering is an agent of wider application than the last named, but an examination of deposits which have been subjected to considerable thrust shows that the flints have been splintered and shattered, but not chipped or flaked. Further if the edge chipping were due to pressure on the flint *in situ*, we should expect to find along the edge of the flint in question, the series of detached flakes ; this, however, is not the case.

(100) There is a large number of deposits of Tertiary and Quaternary age in which the Eoliths have not been subjected to the influence of rapidly flowing water, or to pressure, as they are embedded in a matrix of fine sand or clay which entirely surrounds them, the flints not being in contact with one another. In some of the strata in the Croxley pits Eoliths of the Strepyien period may be found, most of them bearing bulbs quite unrolled, and in their pristine state.

(101) The action of atmospheric influences on flint is well known as producing fractures, but rarely secondary chipping.

(102) The action of herds of stampeding cattle which has been invoked to account for the secondary working of surface Eoliths cannot be seriously advanced when the multitude of tools of Flenusien, Campignyien (with bulbs) and other Neolithic industries is considered.

(103) We submit that in face of the very large number of surface finds, the secondary work on which is identical with that on specimens found in the drift, the advocates of the theory of the formation of Eoliths by natural causes must adduce satisfactory evidence of a natural agent operating at or near the surface, if their claims are to be

substantiated, and this they have hitherto been unable to do.

THE DEMONSTRATION.

In submitting our case for the existence of Eoliths as the work of man, we relied upon the presentation of series of actual specimens, as it is only by seeing and handling the pieces themselves that their real signification can be estimated.

The specimens exhibited may be divided into four series. The first, which was experimental, showed the characteristic traces of the various kinds of work for which the tools had been used, together with the results of re-sharpening on push planes and scrapers.

The second series consisted of Eoliths which were unrolled, and in which the essential characteristics had not been sensibly obliterated or masked.

The third series consisted of specimens from the various Eolith-bearing formations, and showed the chronological sequence of the industries, the extent of their distribution, and the persistence of type.

The fourth series consisted of accepted Palæolithic and Neolithic forms, shewing on their edges secondary working similar to that on Eoliths.

CATALOGUE OF SPECIMENS EXHIBITED.

1. Experimental series in flint showing the characteristic traces of the work done on Hammer stones, Anvils, Choppers, and Borers, and the characteristic traces of re-sharpening on push planes and scrapers. *27 specimens.*

2. Type-series of "Flenusien" tools from the surface of the Kent Plateau, comprising Hammers, Pick Hammers, longitudinal and transverse Choppers, Anvils, Push Planes, Scrapers, Knives, and Borers. The "Flenusien" industry is of Neolithic age, but of purely Eolithic facies. *18 specimens.*

3. Series showing the persistence of Push Planes from the middle Oligocene (Fagnien) down to modern times (Tasmanian). *24 specimens.*

4. Series showing the various types of Push Planes. *31 specimens.*

5. Series showing the persistence of Scrapers from the middle Oligocene (Fagnien) down to modern times (Tasmanian). *24 specimens.*

6. Series showing the various types of Scrapers. *27 specimens.*

7. Series showing the persistence of Knives and Borers from the middle Oligocene (Fagnien) down to modern times. *26 specimens.*

8. Series showing the persistence of longitudinal and transverse Choppers from the middle Oligocene (Fagnien) down to modern times. *13 specimens.*

9. Series of implements from Croxley (Herts.) of the Strepyien period, each with a bulb of percussion. The Strepyien is the transition period from the Eolithic to the Palæolithic culture. *29 specimens.*

10. Series of tools of Eolithic type from the surface of the soil at Chalfont, near Croxley, mostly with the bulb of percussion. Series of tools from the surface of the soil at Ash (Kent Plateau) of the Campignyien period, mostly with the bulb of percussion. The Campignyien industry followed, and is possibly a development of the "Flenusien," and is distinguished from it by the feeling after "form" in the tools. *30 specimens.*

11. Series showing the similarity of form in "Kentien" (Tertiary) and "Flenusien" (Neolithic) implements, both from the Chalk Plateau of Kent. *16 specimens.*

12. Series of Palæolithic and Neolithic bulbed flakes and implements of accepted form from Egypt and elsewhere, showing traces due to work done and secondary work for re-sharpening similar to those found on Eoliths.
25 specimens.

13. Series of various Eolithic implements, Re-sharpeners, Throwing Stones (?), Stones for producing fire (?), and Anvils. *20 specimens.*

14. Series of Tasmanian Eolithic tools, collected by Dr. Fritz Noetling in 1906 from the "Native Quarries."
15 specimens.

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IX. The Dowels of some Egyptian Coffins of the XIIth Dynasty.

By T. G. B. Osborn, B.Sc.,
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Received and read January 26th, 1909.

Though we early obtained a fairly complete general knowledge of the timbers employed by the ancient Egyptians in building and carpentry, it does not appear that any attention has as yet been paid to the details of such knowledge. In the reports of the British Egyptological committees the term "wooden objects" is generally used, no mention being made of the species of timber employed in their construction. The British Museum Guide to the First and Second Egyptian Rooms states that the wood in general use for coffins was "sycamore." This name is rather misleading to English readers, who are more familiar with *Acer pseudoplatanus* under that name than with *Ficus sycomorus*, the sycamore fig.

Wilkinson, in his "Manners and Customs of the Ancient Egyptians," a book published as long ago as 1837, gives more details, telling us that sycamore was in use for coffins, boxes, tables, etc., where large planks were needed. Acacia was used for the planks and masts of ships (this we find recorded in Herodotus), weapon handles and furniture. Groves of this tree were cultivated at Memphis and Abydos, while several species besides the common *A. Arabica* (*Nilotica*) were employed. Boissier's "Flora Orientalis" gives five species of trees, besides shrubs, belonging to the genus Acacia, as occurring in the Nile Valley.

February, 24th, 1909.

Kendrick's "Ancient Egypt," though published some years later than Wilkinson, follows him in his information on this subject.

The Manchester Museum has recently been enriched by the complete set of objects from the tomb of Nekht-Ankh and Khnumu-Nekht, found by Prof. W. M. Flinders Petrie at Rifeh. This set is a particularly fine example of XIIth Dynasty work.

Through the kindness of Dr. W. E. Hoyle, the Director of the Museum, I was afforded the opportunity of examining in detail some chips from the sarcophagi, with a view to determining the species of wood from which they were made. Microscopic sections of the woods were prepared, and from these, with the aid of Nordlinger's "Holzquerschnitte," and the photomicrographs made by Mr. J. A. Weale, of Liverpool, identification was possible.

Satisfactory sections of reasonable size were difficult to obtain, as softening the wood, which is very hard and brittle, in water led to its crumbling to powder. It was necessary, therefore, to cut the sections without any previous treatment, using a heavy razor or a scalpel. The section thus cut was transferred dry to a slide glass, and then moistened with water for examination under the microscope. There was no difficulty in recognising two types of wood among the fragments. These were eventually determined as—

Ficus sycomorus.

Acacia sp.

The species of Acacia is, unfortunately, not determinable. *A. Arabica* is the only Egyptian species with which I have been able to compare it in detail. It is not this, but might be any of the others.

An examination of the sarcophagi shows that they are made of sycamore, while the Acacia was employed for

the wooden pegs or dowels with which the planks were joined. Acacia is a harder wood than sycamore, hence its use for this purpose.

The Manchester Museum also contains a number of boxes found at Kahun, a XIIth Dynasty town. These I was also able to examine, and here again the dowels are of Acacia wood. A full description of these boxes is given in the "Kahun, Gurob and Hawara" report (Petrie 1). They have flat lids of strips of wood passing lengthways, "secured by two ledges across the inside. One ledge has pegs along its outer side which fit into holes in the box, thus the lid cannot be raised at one end. The other end of the lid has a knob on it, which could be tied down to another knob on the end of the box when it required fastening."

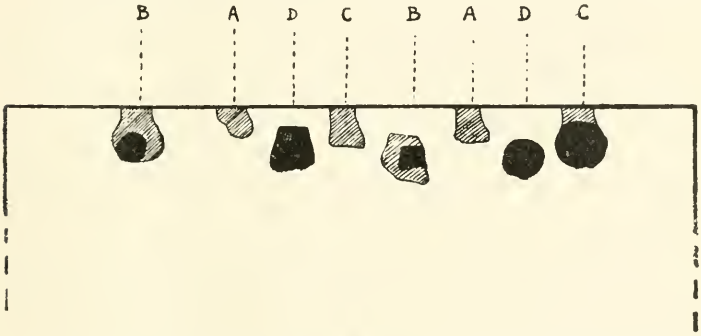

Fig. 1.—Box No. 259, side showing the holes into which the pegs of the lid fitted. In this case there were two pegs on the ledge of the lid, about 6 cms. apart.

When the holes *AA* wore down to slots, the pegs were shifted on the ledge to fit into fresh holes *BB*, and so on. The shaded portion represents the slots caused by the enlargement of the holes, the black portion the holes the sides of which are not yet worn down.

Internal measurement of side 18·1 cm. Fig. reduced ½.

These pegs and knobs are made of the hard Acacia wood, so that they may better withstand the wear they would get, while the boxes in two cases are of cedar wood, and in a third of sycamore, technically a "hard wood"

(*i.e.* dicotyledonous), though softer than the Acacia. A point of some little interest arises from this. The pegs are of a hard wood fitting into holes bored in a softer one. The result of constant opening and shutting of the box has been in one case to enlarge the hole, box No. 259 (*Fig.* 1), so that the peg no longer held. Fresh holes were made, so that the inside of this box shows some eight holes bored in it.

In box No. 255 the wearing away was obviated by the letting in of a strip of Acacia wood over the hole

Fig. 2.—Box No. 255, the side showing inlet portion of Acacia wood over the hole bored in the cedar wood side. The Acacia has longitudinal shading.
Inside measurement of side = 23·5 cms.
Length of strip of Acacia wood = 9·7 cms.
Fig. reduced $\frac{1}{3}$.

(*Fig.* 2). Thus the peg would rub upon wood of equal hardness.

Box No. 254 is of sycamore, the top strip of wood on the side into which the peg fitted is of Acacia. This would be an improvement on the preceding case, since the piece of wood inlet might tend to slip out.

Since the boxes are of the same approximate date, the series has additional interest. It may be regarded as a progressive one, the last type of box being a distinct improvement on the first.

Since the above was written I have had the opportunity of examining the body coffin of Nekht-Ankh. Each half is hewn out of a single log of sycamore wood.

The halves are held in place by two tenons each side, let into slots, while these are fastened by pins of wood about ·5 cms. in diameter, passing through holes drilled through the sides. The tenons are sycamore, but the pins are of Acacia. This furnishes another instance of the use of Acacia wood by the Ancient Egyptians in places where great hardness and strength was required.

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Manchester Memoirs, Vol. liii. (1909), *No.* **10.**

X. On the Diatomaceous Deposit of the Lower Bann Valley, Co.'s Antrim and Derry, and Prehistoric Implements found therein.

By J. Wilfrid Jackson, F.G.S.,

Manchester Museum.

(Communicated by Dr. W. E. Hoyle, F.R.S.E.)

(Received and read January 26th, 1909.)

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- *a. Flint Implements.*
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- *c. Grindstones and Whetstones.*
- *d. Inscribed Whetstone.*
- *e. Grain-rubber.*

IV. Conclusion.

V. Bibliography.

I. Introduction.

For several years past the late Mr. R. D. Darbishire has been particularly interested in the extensive diatomaceous deposit along the valley of the lower Bann, and in the prehistoric implements found so abundantly therein,

and with the kind assistance of Messrs. R. Welch and R. Bell, both of Belfast, he accumulated a considerable amount of material, both in specimens and details of various sections. His keen interest in the matter led him, in 1903, in spite of his advanced years, to go over and personally investigate the district under the guidance of the above-named gentlemen. It was his intention, ultimately, to record his observations and give a detailed account of the various finds. Failing health and other causes prevented him from carrying out his project, and in 1907 he requested me to carry on his observations, placing all his MS. notes, and fine collection of implements, since presented by him to the Manchester Museum, entirely at my disposal.

At his request I spent some time in this district early in 1908, and made many further useful observations.

His death has, unfortunately, somewhat interfered with my original plans, and I have, therefore, thought it advisable to place on record the observations made, so far as they have gone, and to describe the more interesting objects in his collection, along with others contained in the magnificent series belonging to Mr. R. Bell, and coming from the same locality.

Various accounts of implements found in this neighbourhood have been written by several authors, including, amongst others, the late Sir John Evans; the Rev. James O'Laverty; Mr. Robert Day, junr., of Cork, and Mr. W. J. Knowles, of Ballymena, a bibliography of whose papers will be found at the end.

The peculiar character of many of the objects described in this paper has not been touched upon by previous writers, they having only been revealed during the recent extensive working of the diatomaceous deposit.

II. Description of the Diatomaceous Deposit.

Associated with the bogs and alluvial flats along the valley of the lower Bann—the division between Co. Antrim and Co. Derry—is an extensive deposit of diatomaceous earth, known locally as "Bann Clay." It extends all along both banks of the river from Toome almost to Coleraine. At Toome the deposit, so far as can be judged from superficial indications, extends at least a mile west of the Bann, forming what are known as the Creagh meadows. It is perfectly flat and only a few feet above the level of the river. It is here some 3 feet in thickness, and rests on about 1 foot of peaty material overlying sand. The deposit appears to be finest and lightest at the bottom, the upper portion being coarser and full of impurities, and also much stained in places with iron. Nearer Toome, on the Antrim side of the river, it is about 4 feet 6 inches in thickness, and of much the same composition. At both these places it is at the surface. (*Plate I.*)

Good sections are visible along both banks of the river to Lough Beg. These, however, can only be examined from about April to September when the Bann level is below the bottom of the beds. At other times the water is sometimes almost level with the top of the banks.

Below the peat to the west of Church Island, on Lough Beg, the same deposit is met with, and at the north end of the Lough, near the Ferry, I observed it under 8 to 10 feet of peat in April, 1908, in a section about a hundred yards from the river. Here, however, the bed was only 18 inches thick. The overlying peat was full of the roots—corkers—of large trees. Owing to the saturated condition of the ground I was unable to

ascertain the exact nature of the beds immediately below the diatom deposit.

Between Lough Beg and Portglenone it is from 4 to 6 feet in thickness, resting in some places on a dark gray stiff clay, and in others on a layer of peaty soil. The banks of the river near Culbane and Portglenone are about 5 feet high and consist of a small covering of surface soil, then the diatom deposit, and below that a clayey peat. At some little distance from the river the deposit passes under peat of the ordinary kind.

Opposite Culbane, on the Antrim side, the same deposit is 6 feet thick under 3 to 6 inches of soil, and rests on what appears to be a blue marl.

North of Portglenone the deposit nearly disappears, being only 1 foot deep at Annaghcraw. Near Portna it lies 2 feet deep over peat, and again makes its appearance along the narrow flat stretch north of Kilrea— 15 miles from Toome—and ultimately dies out south of Coleraine.

This vast deposit is of great commercial value, and several firms are working it at Toome and Lough Beg. At Toome it has been worked for several years by Messrs. J. & F. Grant, to whom I am indebted for much information. The following chemical analysis was made by Messrs. R. R. Tatlock & Thomson, of Glasgow, on a sample taken from their works :—

	Raw.		Calcined.	
Silica	74·90	per cent.	87·66	per cent.
Alumina	6·68	,,	7·82	,,
Iron Oxide	1·90	,,	2·22	,,
Lime	1·01	,,	1·18	,,
Magnesia	·72	,,	·84	,,
Alkalies	·24	,,	·28	,,
Organic matter and combined water	7·20	,,	—	
Moisture	7·35	,,	—	
	100·00		100·00	

"Microscopical examination shows that sample contains little or no sand."

The deposit, which is of a dull, bluish-gray colour, with a brownish tinge when *in situ*, is dug out in the shape of bricks with a turf spade, and spread out on the surface of the neighbouring fields to dry, when it becomes quite white. In this state it has a specific gravity of ·5422.

When thoroughly dry it is milled to a fine powder, and put up in sacks for export.

At Culbane, and further north, the deposit, though to all appearances of the same composition, is not used in the same manner, but is dug out by the local farmers, mixed with clay, and made into bricks.

In the course of working the deposit at the various places, and especially near Culbane, large numbers of flint and stone weapons have been found embedded in the deposit itself, and in the overlying peat. A number of these are described in the following pages.

Through the kindness of Mr. S. Chaffers, of the Victoria University, Manchester, I am able to give the following fairly representative list of the principal diatoms occurring in the deposit at Toome:—

Surirella biseriata Breb. var. *bifrons* Kütz.
„ *elegans* Ehr.
„ *robusta* Ehr.
Pinnularia nobilis Ehr.
„ *major* Kütz.
„ *hemiptera* Kütz.
„ *streptoraphe* var *minor* Cleve.
Epithemia Hyndmanni Wm. Smith.
„ *turgida* Kütz var. *granulata*.
„ *Mülleri*.
Navicula (Caloneis) Silicula Ehr. var *alpina* Cleve.
„ „ *latiuscula* Kütz.

Navicula (Diploneis) elliptica Kütz.
„ *(Neidium) Iridis* Ehr.
Gomphonema geminatum (Lyngb.) Ag.
Stauroneis Phoenicentron Ehr.
Cymbella Ehrenbergii Kütz.
„ *aspera* Ehr. = (*C. gastroides* Kütz).
„ *lanceolata* var. *cornuta*, Ehr.
Cymatopleura elliptica Breb.
„ *hibernica* Wm. Smith.
Stephanodiscus astrea Grun.
Melosira Normanni Arnott.

III. DESCRIPTION OF THE PREHISTORIC IMPLEMENTS.

a. Implements of Flint.

By far the most abundant implements found in working the diatom deposit at Culbane and other places in the Bann valley consist of flint, and may be roughly divided into several classes. The respective terms, however, applied to them, as well as to the succeeding series of implements, are intended more to assist in their classification than to determine the uses to which they were applied.

Flakes.—Flint flakes appear to be the most numerous; they have been found in large quantities in the deposit near Culbane. Some thousands have also been discovered in the neighbourhood of Toome, but the majority of these were obtained from the supposed crannoge-sites on Toome Bar (Day '67, and Evans '68).

The Darbishire and Bell collections contain examples from each of these localities. The flakes are of all sizes, long and short, narrow and broad, and vary considerably in thickness. They vary in length from 1 inch to as much as 5 or 6 inches. Some examples present little or no secondary working, while others exhibit a considerable

amount, having been chipped along one or both edges, and occasionally, to some extent, on the face; the base in many cases is worked into a distinct tang. *Plate II.* exhibits a few typical examples from Culbane.

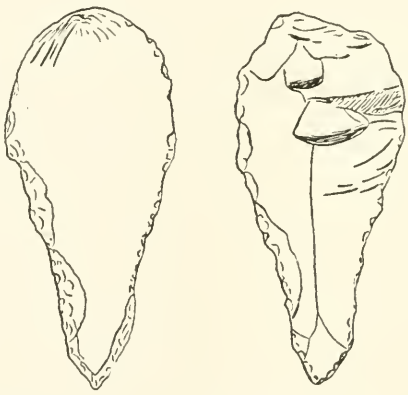
Scrapers.—A few of the flint flakes have been chipped into a rounded outline at the ends or sides, so as to form "scrapers." The various forms given by Evans ('97), the horseshoe-shaped (figs. 204, 205, etc.), the kite-shaped (fig. 212), the disc-shaped (fig. 219), as well as the flat and hollowed forms (figs. 225 and 226A), are all represented in the collections from Culbane. In Mr. Bell's collection is a Culbane example, $3\frac{1}{2}$ inches long and 3 inches wide, trimmed on three of its edges; it looks as if designed either for a scraper or chopper.

Knives.—Several of the long narrow flakes should be classed undoubtedly as knives. The Darbishire collection contains a number of interesting examples from Culbane. They vary from 2 to 5 inches in length, and the cutting edge, usually curved, is formed by the natural fracture of the flint. The opposite edge, which, if left sharp, would be found very troublesome, has been dressed and blunted, especially near the pointed end of the flake where the index finger of the user was no doubt placed. The broad end has been formed into a tang, either for insertion into a handle, or, if of sufficient length, for use without. (*Plate II.*)

Borers.—Under the head of borers might be classed a number of small, slender, pointed implements of flint found at Culbane. They are an inch or more in length and about three quarters of an inch wide at the base, and are finely chipped along both edges. They might have served either as small borers or as arrow-points. Fig. 228, given by Evans ('97), illustrates this type. Large borers, heavy at the butt and chipped to a long point at the

other end, similar to that figured by Evans ('68, pl. 18, f. 9), have also been found at Culbane.

Some of the thicker ridged flakes, *i.e.*, triangular in section with a single ridge formed by two facets on the convex face, have also been formed into boring tools. In these cases the edges and opposite faces of the flake have been chipped away, especially near the pointed end, so that the cutting edges are at opposite angles. These tools appear better adapted for boring continuously in one direction. As the Culbane examples appear to be rather an interesting and unusual type, a figure is given below of a specimen in the Darbishire collection. (See also *Plate II.*)



Celts and Chisels.—Mr. Bell possesses several examples from Culbane of the long, narrow chisel type of celt, with somewhat straight sides. One specimen, 6 inches long and $1\frac{3}{4}$ inches wide, roughly chipped to shape, has the cutting edge formed by the intersection of two facets—a characteristic feature of the "Kitchen-midden type," described by Coffey and Praeger ('04) in their paper on the "Larne Raised Beach." Another example, 5 inches long and $1\frac{1}{2}$ inches wide in the middle, has been dressed

almost to a point at each end, and might have been used as a borer or pick. A somewhat similar example, but not so pointed, is in the Darbishire collection; it is also from Culbane.

So far no specimens of oval flint celts have been found at Culbane. Mr. Bell, however, has a good example from Toome Bar, which measures 4½ inches long and 2 inches wide, and is roughly chipped on both sides. It bears some resemblance to the "Larne type," figured in the above-mentioned paper (fig. 8, no. 6).

None of the flint celts examined show any signs of polishing.

Arrow-heads.—Three types of beautifully finished flint arrow-heads have been found in the deposit at Culbane; these are all represented in the Darbishire collection. They comprise (1) the leaf-shaped, (2) the indented, (3) the stemmed, and are all well illustrated in the British Museum "Guide to the Antiquities of the Stone Age, 1902," on pl. 9, figs. 2 and 3, pl. 10, figs. 5 and 9, and pl. 3, fig. 5. Some are made of the same peculiar pale-brown flint as that of the ordinary flakes, while others are almost transparent. They are all exquisitely fashioned, the chipping running right over them.

Along with the arrow-heads, etc., in the Darbishire collection, are several flaking implements, "fabricators," and a number of water-worn pebbles of quartzite, etc., with abraded ends, "hammer-stones," all of which have been found in the deposit at Culbane. These clearly indicate industry in the immediate neighbourhood.

b. Clay-slate and other implements.

Besides implements manufactured of flint, a large number composed of coarse clay-slate, basalt, sandstone, etc., have also been found in the diatom deposit at Culbane,

the materials from which these were made being, in all probability, obtained from the glacial drift which masks the Lower Basalt of the neighbourhood. The majority of those in the Darbishire collection are of clay-slate, a material which appears better adapted, probably, than any other for the easy manufacture of certain implements, many of the specimens having been merely ground to a cutting edge.

The implements of this section might be conveniently grouped under two heads—celts and chisels.

Celts.—A small proportion only of the clay-slate series have the typical shape of a celt. In Mr. Bell's collection are several examples varying from 4 to 6 inches in length and from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in width, all of which have been roughly ground and polished. They mostly possess a semi-circular cutting edge, but one specimen, $5\frac{1}{2}$ inches long, has a straight cutting edge bevelled on each side. In my own collection is a very good specimen obtained by Mr. Bell, 2 feet from the surface in the deposit at Culbane. It measures $7\frac{1}{2}$ inches long, 3 inches wide (except at the butt which is only 1 inch), and $1\frac{1}{4}$ inches thick; it weighs 2lbs. It has been roughly ground all over, but portions of the original surface are visible in hollow places. The cutting edge shows signs of hard usage, being much broken. (*Plate III., Fig.* 11.)

Celts of basalt and other rocks are, on the whole, more numerous than those of clay-slate. Owing, presumably, to the greater hardness of such rocks they would be found more serviceable for the manufacture of celts.

The majority in the Darbishire and Bell collections have been wholly or partially polished, but some have been roughly chipped to shape only. They are all of much the same general shape, *i.e.*, the middle of the

implement swelling into an oval form, tapering to a more or less narrow rounded butt at one end and to a semi-circular cutting edge at the other. On the average the sizes vary from 5 to 11 inches in length, and from $2\frac{1}{2}$ to 4 inches in breadth. Some appear to have been formed for dealing a heavy cutting blow ; other smaller examples may have been employed as smoothing and polishing tools, adzes, or chisels. Two celts of sandstone found at Culbane are in the Darbishire collection. Another very interesting example in this collection is a re-chipped polished celt of felstone, which was also found at Culbane. It has evidently been broken when in use, and afterwards chipped away in an attempt to make some other type of implement. The smallest celt in the above collection is one composed of slate ; it is 2 inches long, 1 inch wide, and $\frac{3}{8}$ inch thick. It has been ground all over, and was found in the deposit near Culbane. A similar implement of slate, but slightly larger, was found at Toome by Mr. Bell.

Numbers of stone celts from Toome have also been described by Wilde ('57), Day ('67), and Evans ('68).

Chisels.—A good example of a sandstone chisel was found 3 feet from the surface in peat overlying the diatom deposit at Culbane, and is now in the Darbishire collection. It measures $6\frac{1}{4}$ inches long, and $\frac{3}{4}$ inches wide, and is nearly square in section. It has been ground to a cutting edge at one end and smoothed on two sides.

The greater number of the clay-slate implements have a chisel-like appearance. The examples in the Darbishire collection vary considerably in size and shape, but are all of the same rude character, being for the most part composed of flattish pieces of rock with one end ground down to a cutting edge. The sizes vary from about 2 to 8 inches long, and from $\frac{1}{2}$ to 2 inches wide, some

specimens being only $\frac{1}{2}$ inch in thickness. Traces of grinding are visible in places on the sides of the larger specimens; the smaller examples have, in many cases, been ground all over. (*Plate III.*)

A well-finished implement of clay-slate of a triangular shape was obtained 6 inches in the deposit near Culbane. It measures $4\frac{3}{8}$ inches long, $2\frac{1}{2}$ inches wide at the cutting edge (which is semi-circular), and is only $\frac{3}{8}$ inch in thickness. This specimen is in my own collection. (*Plate III., Fig. 7.*) In the Darbishire collection is the fore-part of an almost similar implement, which was also found at Culbane, along with a rough triangular piece of clay-slate, showing traces of grinding along one side, and at the broad end on both faces, with the intention presumably of forming a cutting edge.

Under the head of chisels might also be included a coarse clay-slate implement in the above collection, $10\frac{1}{2}$ inches long, $2\frac{5}{8}$ inches wide, and $1\frac{1}{8}$ inches thick, weighing $2\frac{3}{4}$ lbs.; it was also found at Culbane. It has been roughly chipped in places, and one end ground down to a sharp cutting edge. (*Plate III., Fig.* 10.) Used as a wedge for splitting timber it would prove most effective, and it appears to me highly probable that many of the larger chisel-like implements were used for that purpose.

The most remarkable implement of clay-slate, however, in the Darbishire collection, is one which was found near Culbane in 1901, about 3 feet from the surface in the diatom deposit overlaid by bog. It measures 17 inches long, and is $4\frac{3}{4}$ inches wide at one end, narrowing down to $2\frac{3}{4}$ inches at the other. It has been, in all probability, several inches longer, as it appears to have been broken at the narrow end. The thickness is only 1 inch throughout and it weighs 6lbs.

Implements of this description are exceedingly rare

in Ireland. The only reference I can find to an implement of a similar character is that given by Sir W. R. Wilde ('57, p. 43.) His description is as follows:—"The largest celt yet discovered in Ireland is formed of coarse clay-slate. It is 22 inches long, $3\frac{3}{4}$ inches broad at its widest portion; but is only 1 inch thick; the arras has been removed on the edge, as shown by the diagram of its section (fig. 45). It might have been intended as the coulter of a plough for soft ground, but bears no evidence of ever having been so employed. This beautiful specimen was found in deepening the bed of the river Blackwater, two miles below Charlemont, County of Armagh."

The Culbane implement has been roughly chipped in some places, and smoothed in others, along both its edges. The broader end has been treated similarly but not sufficiently to produce a cutting edge. Curiously enough, if the broken end was continued to a point like the Blackwater implement, it would be exactly 22 inches in length. Its precise use is problematic, but the suggestion made by Wilde seems a likely one and might apply equally well here. The implement might also have been used as a rough sort of spade, or hoe, for working in soft ground. (*Plate III., Fig.* 12.)

c. Grindstones and Whetstones.

Grindstones.—Several stones of various shapes and sizes, for grinding and polishing implements, have been found at Culbane, but so far as I can ascertain, none have hitherto been described from that place.

The following are some of the chief:—No. 1 was found in sand up in Culbane Village; Nos. 2 to 5 in the diatom deposit near Culbane; No. 6 fifteen inches from the surface in peat overlying the deposit at Culbane.

(1) A fairly heavy mass of fine-grained reddish sandstone, 15 inches long, 6 inches wide, and 5 inches thick, weighing 20 lbs. It is sub-quadrate in section, and all four sides have been used. The grinding surfaces are long and fairly flat, ending each way with a slight upward curvature. (Darbishire collection.) (*Plate IV.*)

(2) A smaller semi-circular slab of reddish sandstone, somewhat similar to the above, 9 inches long, 5 inches wide, and 1 to 2 inches thick; weight 5 lbs. Both the upper and lower surfaces have been used. (Darbishire collection.)

(3) A flat angular slab of soft yellowish-gray sandstone, 10 inches long, 9 inches wide, and 2 inches thick; weight 6 lbs. The centre of one face is considerably hollowed out by use. (Bell collection.)

(4) A small specimen of light-gray sandstone, 5 inches long, 4 inches wide, and 1 inch thick. (Bell collection.)

(5) Two smaller fragments of light-gray sandstone, each exhibiting several, more or less deeply worn, concave surfaces. (Darbishire collection.)

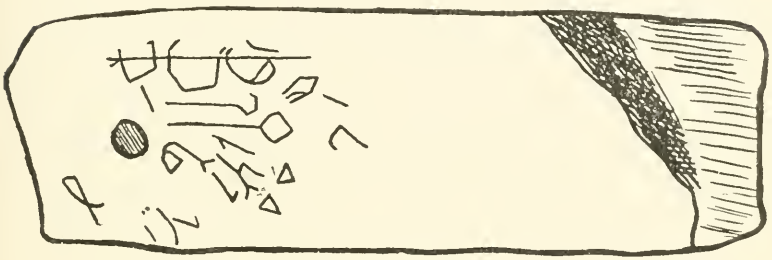
(6) A small flat piece of sandstone, $4\frac{3}{4}$ inches long, $3\frac{1}{4}$ inches wide, and $\frac{3}{4}$ inch thick, having a saucer-like depression in the centre, $2\frac{1}{4}$ inches in diameter each way, and $\frac{3}{8}$ inch deep. Its precise use is doubtful; by some authorities it is looked upon as a palette for grinding colours. (Bell collection.)

Whetstones.—Mr. Bell possesses two typical whetstones of clay-slate, which were discovered at Culbane in the deposit. One is 7 inches long and $1\frac{1}{4}$ inches wide, with a hollow groove from edge to edge running the entire length (*Plate III., Fig.* 3); the other, found 3 feet from the surface, measures $7\frac{1}{2}$ inches long and $1\frac{1}{2}$ inches wide, and has a flat smoothed upper surface with deeply incised markings in one or two places (*Plate III., Fig.* 1).

A similar example, but much larger, is figured by Wood-Martin ('95, fig. 152) from the site of a lake-dwelling in the island of Achill.

d. Inscribed Whetstone.

Another example of a clay-slate whetstone in Mr. Bell's collection is of peculiar interest. It was found near Culbane 2 feet from the surface, embedded in the deposit and measures 4 inches long and $1\frac{1}{4}$ inches wide, and possesses two flat surfaces. One end is perforated with a circular hole. On one of the flat surfaces near the perforated end are a number of small delicately inscribed



characters which can easily be distinguished by the naked eye. Apparently the whole surface of the stone has been covered with similar characters, but, owing to wear, those at the opposite end have become partially obliterated, but with a lens traces of their presence are indicated. Such of the markings as are clearly visible are given in the following sketch, drawn slightly larger than their natural size, but occupying approximately the same relative positions.

According to Wood-Martin ('95) Oghamic scribings have been found on bone pins and other ornaments from the lake-dwellings of Ballinderry and Strokestown. He gives two figures (figs. 13 & 14, p. 41) representing

some of the rune-like characters, and states that photographs of these examples were submitted to Prof. Stephens of Copenhagen, but he could not decide whether they were actually runes; and neither Sir John Rhys nor Sir Samuel Ferguson were able to interpret the seemingly well-marked Oghamic scorings.

Ogham appears to have been used for mortuary inscriptions carved on pillar-stones, as well as for communicating by messengers, and it seems at least possible that the Culbane inscribed stone may well have been used for the latter purpose. (*Plate III., Fig.* 2.)

c. Grain-rubber, or saddle-quern.

A fine example of a "Grain-rubber" was found some little time ago in the peat overlying the diatomaceous deposit, 18 inches from the surface, near Portglenone. As it has never been previously described, I take the opportunity of putting it on record here.

It was obtained by Mr. Bell and is at present in his collection. It is composed of what appears to have been originally a coarse dolerite, the whole of the felspar of which has now become weathered out, leaving the entire surface of the stone full of innumerable holes and cavities. This is, in all probability, due to the action of the peat in which it lay. It measures 23 inches long, 12 inches wide, and 4 inches thick, and weighs 62lbs. As will be seen from the photograph (*Plate IV.*), its upper surface is hollowed out in the form of a curve.

No top-stone, or rubber, occurred with it, but a rounded specimen of Antrim Chalk, 5 × 4 × 2 inches, was found in the diatomaceous deposit below the peat. This, though it has the general appearance of a rubber, seems scarcely large enough, or of the right material, to have been used in connection with the above.

IV. Conclusion.

With regard to the precise age of the various implements found at Culbane, nothing, unfortunately, can be decided until further observations have been made. There appears, however, to be sufficient evidence to mark a long period of development—probably from Early Neolithic right into the Bronze Age.

Wherever possible some idea of the horizon in the diatom deposit at which they occurred has been given, but, as can readily be understood, many of them have only been found on the disintegration of the material in the process of brick-making, and their position, therefore, cannot be stated. Even where the horizon is given, it is, unfortunately, not of any great archæological value, as while the deposit was being formed, and possibly long afterwards, it would be so soft that anything falling on its surface would sink in some places right to the bottom, and in other places possibly not so deep. The irregular shape, too, of many of the implements may be due rather to the original form of the stones from which they were made, than to any particular design.

So far as I can ascertain, no Bronze implements have been found in the deposit itself, though numbers of Bronze weapons of various kinds have been found in the bed of the Bann at Portglenone, and at Toome, indiscriminately mixed with flint arrow-heads, stone celts, etc., but these are possibly the relics of various fights at fords which, in all probability, existed at these places. These finds have been fully dealt with by O'Laverty ('57), Day ('67), Wood-Martin ('86), Munro ('90), and others.

Regarding the probable uses of the numerous flint flakes found in the vicinity of the Bann, the suggestion made by Sir John Evans ('68) that they were used mounted

for spearing fish, seems a very likely one, considering the fact that Toome is so noted for its salmon fishery. This fact would tend to make the Bann valley an important fishing centre in former times as it is to-day.

It is probable that many, if not all, of the larger and broader flakes were used as knives, as pointed out by the Rev. G. R. Buick ('84) in his description of flint implements found at Glenhue, Co. Antrim, about four miles east of Culbane. He argues that their comparatively great breadth precludes their use as spear heads. Many of them also might have served equally well as scrapers, the sharp cutting edge, formed by the natural fracture of the flint, being especially adapted for this purpose.

They were probably seldom used unmounted. Stevens ('70) mentions the finding of a flake of gray flint in the bed of the Bann, at Toome, which had one end wrapped round with moss *(Hypnum brevirostre)* intended apparently as a substitute for a handle. This is interesting, but further details are desirable.

In conclusion I must gratefully acknowledge the very kind assistance received from Mr. R. Bell in lending me numerous specimens and guiding me over the district. To Mr. R. Welch, M.R.I.A., I am also much indebted for advice and for several of the photographs accompanying this article, and to Dr. W. E. Hoyle, M.A., F.R.S.E., for his kindness in communicating the paper.

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Plate I. Section of the Diatomaceous Deposit at Toome, Co. Antrim. (Photo by R. Welch.)

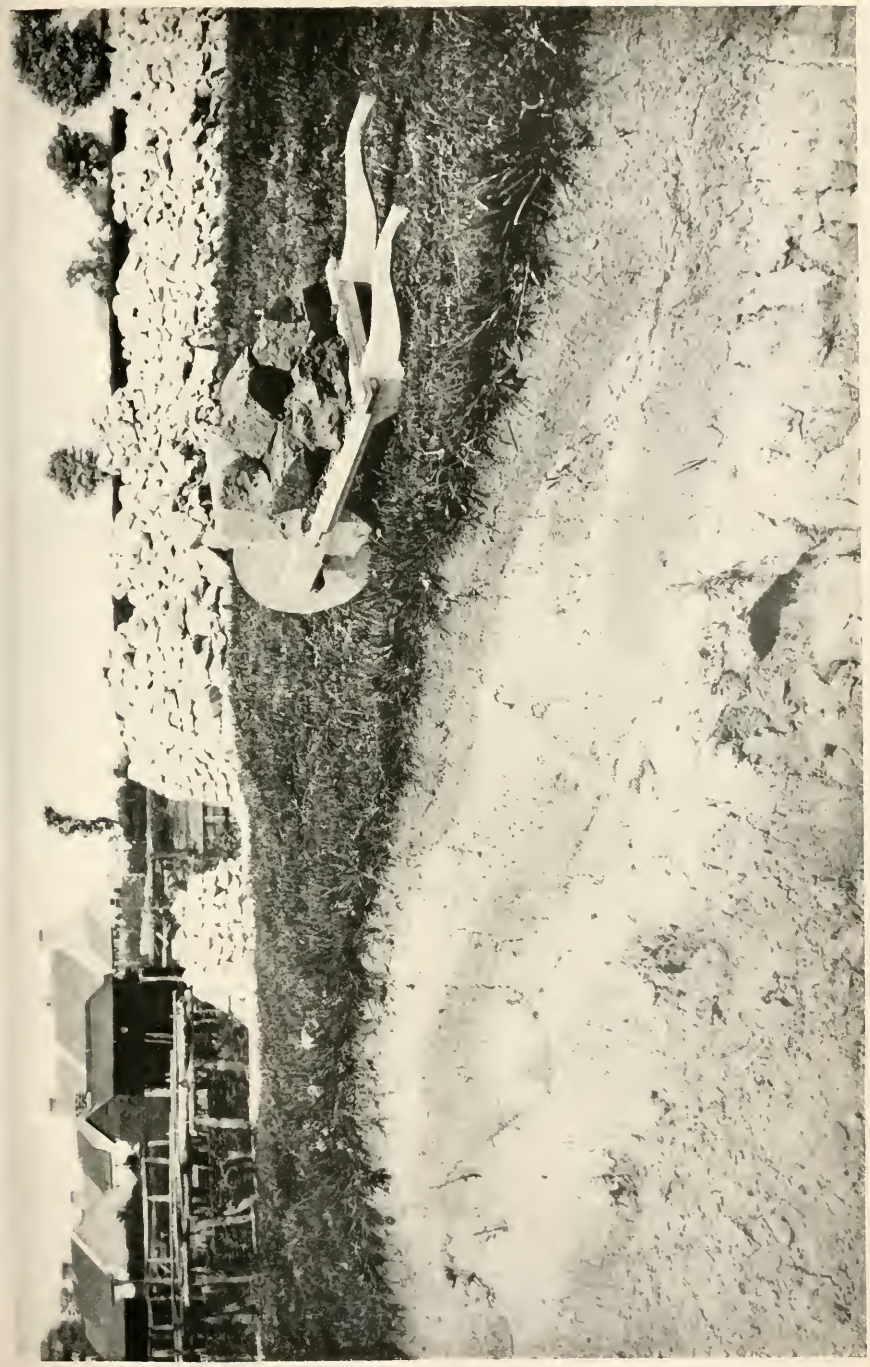

Plate II. Worked Flint Flakes from Culbane, Co. Derry.
[Darbishire collection.]

1st row.—Spear heads.
2nd ,, .—Knives.
3rd ,, .—Borers, etc.

6 inches

Plate III. Clay-slate Implements from Culbane, Co. Derry.
[Darbishire, Bell, and author's collections.]

Figs. 1 to 3.—Whetstones (No. 2—Inscribed).
„ 4 to 10.—Chisels.
„ 11.—Celt.
„ 12.—Hoe.?

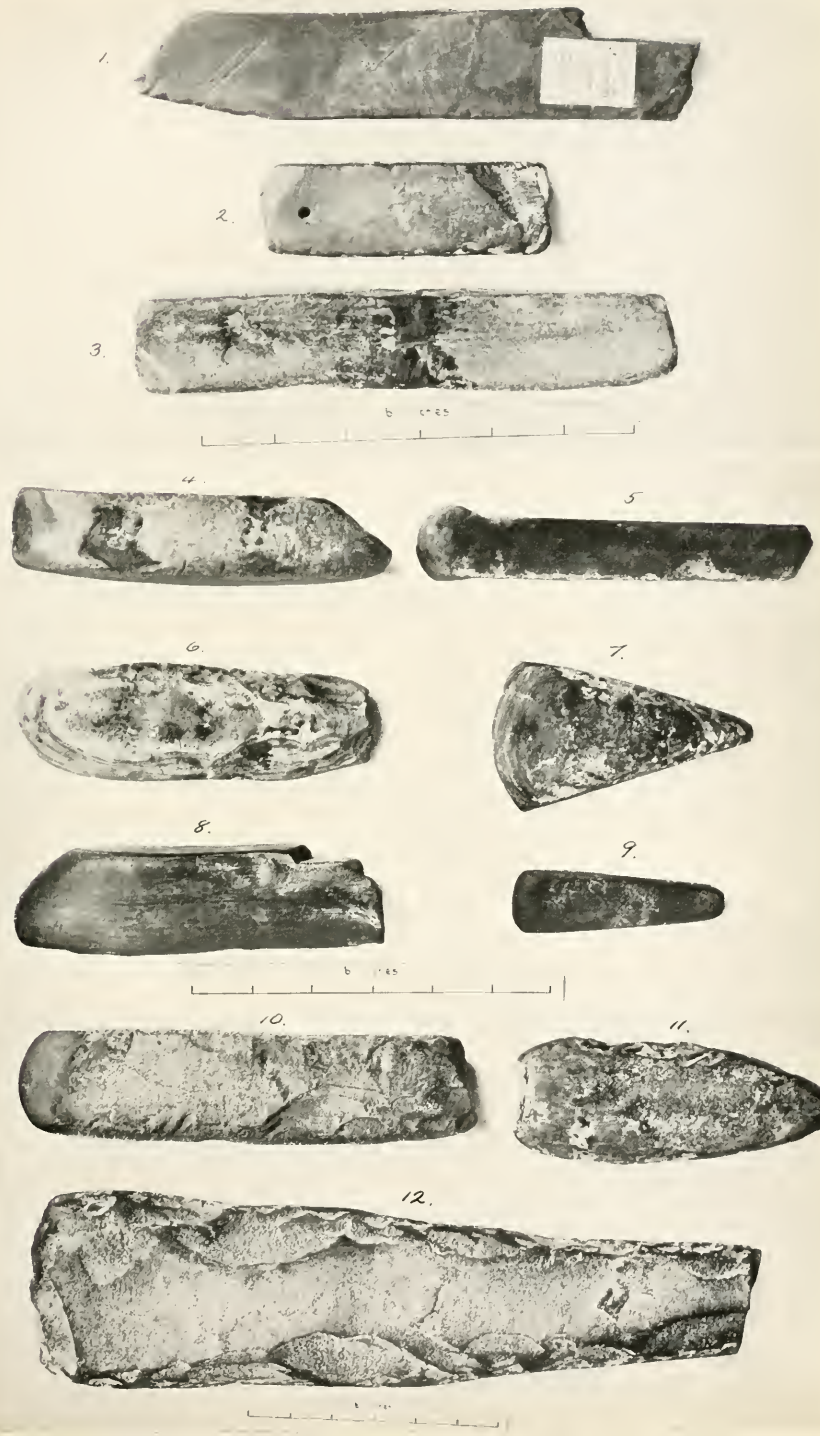
1.
2.
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Plate IV. Upper figure.—Grindstone found at Culbane. [Darbishire collection.] Lower figure.—Saddle-Quern found near Culbane. [Bell collection.] (Photos by R. Welch.)

XI. A Preliminary Account of the Submerged Vegetation of Lake Windermere as affecting the Feeding Ground of Fish.

By Professor F. E. Weiss, D.Sc., F.L.S.

Received and read February 23rd, 1909.

Mr. Francis Nicholson, of the Windermere and District Angling Association, has drawn my attention to the fact that several of the shallow bays of Lake Windermere have of late years become filled with various aquatic plants, which have interfered considerably with the fishing in that district. These gravelly reaches of the lake are the natural feeding ground for trout and other fish, and when covered with a rank vegetation, the fish are unable to get at the worms and other animal organisms, and are therefore driven to seek their food in the deeper water of the lake, where they fall a prey to their enemy the pike and the larger trout. Not only is the number of trout thereby reduced, but the absence of fish from the shallow water considerably limits the possibility of fly-fishing, which should be best in these parts of the lake, for in deep water the trout are practically only caught by trolling.

The efforts of the Angling Association to improve the fly-fishing in Windermere, by turning into the lake many thousands of yearling and two-year-old fish of local and foreign strain, have therefore been checkmated by the deterioration of the feeding grounds for these young fish and their consequent destruction by their voracious enemies.

It seemed, therefore, important to examine the vegetation which is filling up the bays in question, and to find

out, if possible, what measures might be employed to keep it down and so restore the fishing prospects of this popular sheet of water. For the final solution of the problem, the plants in question will have to be carefully studied at different periods of the year, and for several seasons, to see what the effect of certain preventative measures may be, but as a preliminary examination of the lake and its submerged vegetation undertaken during last summer and autumn has suggested a remedy, it seemed well to publish a preliminary account so that the authorities concerned in maintaining the fisheries might be induced to revert to certain practices, which in the past have been effective in keeping the submerged vegetation in check.

In October last I visited together with Mr. Nicholson a number of the affected portions of Lake Windermere. An examination of the submerged vegetation at the north end of Parson Bay, about 50 feet from the shore and in 12 feet of water, showed that the bottom of this bay was covered with a dense matted growth of *Nitella opaca* some 18 inches in height, while above it spread long straggling shoots of the Canadian Pondweed *Elodea canadensis*. When visited in the autumn the *Nitella* was dying down forming a black fœtid mass, while on the long rapidly grown summer shoots of *Elodea*, were the numerous short dense autumn branches destined to reproduce this plant in the next season.

Nearer the centre of Parson Bay, where the overflow from the sewage works falls into the lake, the vegetation was particularly luxuriant. About 20 feet from the bank and in 6 feet of water, the Water-Milfoil *Myriophyllum* was very plentiful, coming up to the surface of the water, while below it was a stratum of *Elodea*, and below that again the dense growth of *Nitella*. It would be quite

impossible in a place like this, or indeed in any part of this bay, for fish to get any ground food.

A little to the north of Ramp Holme Island about 50 feet from the shore in 13 to 15 feet of water, streaming plants of the Pondweed *Potamogeton praelongus* (Wulf) were seen coming up to the surface of the water while the ubiquitous *Nitella* here too covered the bottom of the lake. At this point the Canadian pondweed was not met with ; the slightly deeper water or the less sheltered position of this region may have been unfavourable to its growth. The Pondweed (*Potamogeton praelongus*) occurs up and down the lake at intervals between the Ramp Holme Island and Storrs Hall and affords I am told a good harbour for pike and perch.

A visit to a bay at Cunsey, close to the Fish Hatchery, was of considerable interest. Here the water is shallower, and no *Nitella* was seen, but the bottom of the lake was covered with the Canadian pondweed (*Elodea*), or Polly, as it is locally called. Some two years ago, about Christmas time, the bay was cleaned, and I was told the present growth of *Elodea* is only about one quarter as dense as it was before the dragging. There was a little *Potamogeton* present, but it was not so luxuriant as in the more open reaches of the lake.

The last bay visited was the little rocky bay of Gill Head, on the East side of the lake, nearly opposite Cunsey House. Here the bottom was more stony, and the vegetation of quite a different type. The bank shelved down very gradually, and there was a large area of the bay, between 2 and 5 feet in depth, in which were growing between the coarse pebbles and stones numerous but isolated plants of the Water-Milfoil (*Myriophyllum spicatum*), the Quillwort (*Isoëtes lacustris* L.), and the Shoreweed (*Littorella lacustris* L.). These plants were never

massed together, and would not interfere with the ground-feeding of the fish. But the pebbly bottom, and to some extent the plants above mentioned themselves, were covered with a dense growth of a creeping fresh-water Alga, *Cladophora*, which I was told grew especially rapidly in hot weather, and formed a close carpet over the bottom, thus preventing the fish from getting at the worms, etc. This bay was a favourite place for drawing up the nets, and at the time when they were in constant use this insidious vegetable growth was said to have been practically absent.

A detailed description of the various forms of submerged plants which interfere with the fishing, and their methods of reproduction, is given as the measures to be used in reducing this vegetation depend largely on the season of flowering and their methods of vegetative reproduction.

Probably one of the most persistent and harmful of the submerged aquatics in Windermere is the *Nitella opaca*, Ag., belonging to the group of Characeae or Brittleworts. This is found rooted in the softer, more muddy, parts of the lake at varying depths from 6 to 16 feet, growing some 18 inches to 2 feet in height Like many of the Characeae it smells very strongly of garlic when taken from the water, but this particular species can readily be distinguished, apart from its detailed structure, by the tendency to become nearly black as the plants get older. *Nitella opaca* grows frequently in very deep water, being less dependent upon light than other Characeae. It is a very variable species, and the particular form found in the regions of Windermere mentioned above is probably the variety *elongata* of Alexander Braun, which is generally found on the bottom of large lakes, where it grows to considerable size and covers very large areas, forming regular meadows.

This form has long internodes and leaves, and does not produce fruits very abundantly, a fact which is probably correlated with the scanty illumination it gets in deep water and particularly when overshadowed by *Elodea* and *Potamogeton* as is the case in some of the reaches of Windermere. It is a dioecious species, and fruits in May and June, and the spores are said to commence to germinate in August and September. It is recorded in the Ninth Edition of Babington's "Manual of British Botany," which was edited by Henry and James Groves, the great authorities, as an annual plant, and the appearance of the old plants in the late autumn was certainly suggestive of their dying down, though Dr. Migula asserts* that they may live for three or four years when growing in deep water. I have been unable to discover whether this species reproduces by vegetative methods as is so common among the Characeae. As this deep water form fruits somewhat rarely, and as it covers such extensive areas, it is most probable that it is endowed with some kind of vegetative propagation.

Elodea canadensis, Rich., the Canadian Pondweed or Water-Thyme is called Water Pest by the Germans on account of the enormous damage it did both to fish-ponds and waterways after its introduction into Europe. Nothing is known of the means by which it was introduced, but it seems to have made its appearance first in 1836 near Warringstown, in Ireland. In 1842 it was found both near Dublin and also in Scotland, and in 1847 it was discovered near Market Harborough and also near Chichester. After that it spread to most of the canals and waterways where it flourished so vigorously

* Migula, W. "Die Characeen," *in* Rabenhorst's "Kryptogamen Flora von Deutschland, Oestreich und der Schwerz," vol. 5, 1897.

that it impeded the traffic and interfered with the opening and closing of the locks. The same difficulties arose in France and Germany some ten years later when it had spread to those countries. The history of its invasion into Europe indicates that it has considerable powers of rapid dispersal, and yet this does not take place by means of seeds, for it is a dioecious plant, and so far only the female plant has been known in England, and in the absence of the male plant it is always sterile. In the rest of Europe, too, only female plants have been found, but in *Science Gossip*, in 1880 (vol. xvi., p. 227), Mr. D. Douglas has recorded the occurrence of male plants in Scotland. Possibly small pieces of the weed are carried by waterfowl or other birds from place to place, for even the smallest detached pieces will root under suitable conditions. Apart from the power it has of rapidly spreading over a large area, its wonderfully vigorous growth in a new country has been of great interest, and the remarkable subsequent decrease of the number of plants when once it had become thoroughly acclimatised. Whether this latter reduction of vegetative vigour is connected with the absence of seed formation is a moot point, but at all events it is an observable fact. Its method of reproduction in Europe is mainly by short autumn shoots, about one to two inches in length, which are formed in the autumn near the ends of the long and straggling summer shoots. They are easily recognisable in the autumn by their vivid green colour, and in spring when the old shoots die away these young branches take root and produce new individuals. Besides these short dense autumn shoots *Elodea* produces small specialised buds, comparable to the winter buds of many aquatic plants, to which the name of "turions" has been given. They have been observed by Alexander

Braun, 1870, and subsequently by Ascheron and Graebner,* and are described and figured by Glück.†

They do not seem to have been noted by English botanists, but were clearly visible in specimens gathered in February, and on which the old leaves of the stem were dying away (*Fig.* I. A).

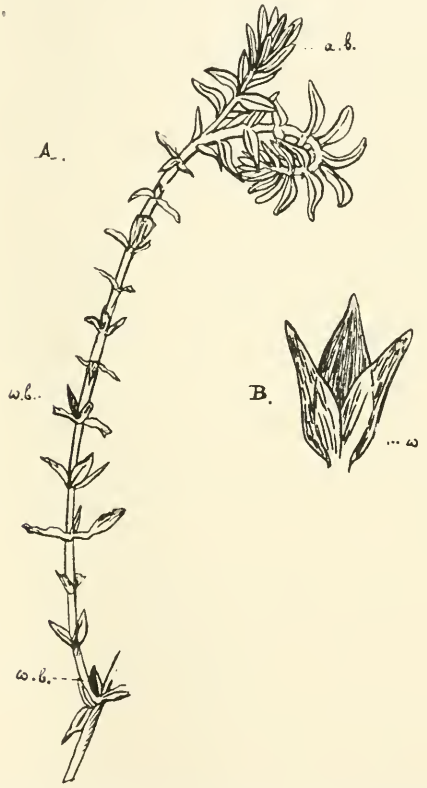

Fig. 1. A. Old shoot of Canadian Pondweed *Elodea canadensis*. The end of the shoot is often bent up and is composed of closely set leaves. An autumnal lateral shoot (*a.b.*) has also been formed besides the winter buds (*w.b.*).

B. Winter bud enlarged showing decussate arrangement of bud scales.

* Ascheron P. and P. Graebner, "Synopsis der Mitteleuropaeischen Flora," vol. I, part 6, p. 403.

† Glück, H. "Biologische und Morphologische Untersuchungen über Wasser und Sumpfgewachse." 1906, p. 86.

They are about $\frac{1}{3}$ inch in length, and differ from the ordinary winter-buds found in so many water plants in not being disarticulated from the parent shoot. They remain attached until the main shoot dies down, growing out in spring into new vegetative shoots.

A detailed examination of these shows that the lowermost leaves are always decussate—*i.e.*, arranged in pairs at right angles to the preceding and subsequent ones. The same arrangement of the leaves will be seen at the base of the branch in *Fig.* I. A, just above the lower winter bud, and is quite usual with the basal leaves of a shoot, while the upper parts have three leaves in a whorl.

The large Pondweed (*Potamogeton praelongus* Wulf), with its characteristic long shoots some 13 feet in length, though plentiful near the ferry, does not occur in sufficiently large quantities to seriously affect the fishing, particularly as it does not cover the bottom, but grows up to near the surface of the lake. It is a perennial plant, and flowers in May and June. Possibly this form may reproduce also by winter buds, as is not unusual in this genus. But I was unable to observe any on the specimens collected in the autumn.

The Water-Milfoil, like the Pondweed, is not a dominant form of vegetation, and the Water-Starwort (*Callitriche*), though dominant in some reaches, as for example near the boat landing, is not so abundant on the feeding grounds of the fish.

As all the plants described flower about May and June, the artificial removal of the weeds should take place not later than July. Experience shows that the best method of effecting this is by drawing up of a net similar to that used in fishing. Dragging the bottom with chains has not been successful, as the weed is broken up but not removed, and, as in the case of the Canadian Pondweed,

each piece can take root again, the dragging only helps the weed to multiply. Probably the swans which are found on the lake aid in the same manner in distributing the *Elodea*. By the dragging with fishing nets the bay near the fish hatchery was cleared of the Canadian Pondweed and the Brittlewort some two years ago, and the Gill Head bay was formerly kept free from the *Cladophora* by similar means. At that time there were fourteen nets worked at different parts of the lake, but latterly, by arrangement with the Fishery Board, only two are allowed to be used. A reversion to the former practice would undoubtedly have a beneficial effect in keeping the weed down.

At the outset it might probably be best to drag the bays carefully both in the summer before the seeds and spores of the ordinary water plants have ripened, and then again in the autumn before the *Elodea* has broken up and its autumn branches and winter buds have become separated. Later on, if the nets are used regularly for fishing, very little expense need be incurred in keeping the bottom of the lake clean in the bays mentioned above. The use of the 14 nets, instead of reducing the number of fish, would actually increase the number by preserving the feeding grounds, and thus give a better chance of life to the thousands of young trout that are annually turned into the Lake.

In conclusion I should like to add that I have received the greatest assistance from Mr. Francis Nicholson in the examination of various portions of the lake, and his intimate knowledge of the past and present conditions of the fishing has been of the utmost value in arriving at the conclusions expressed in the later paragraphs of this paper. These conclusions may indeed be taken to represent our joint opinion, arrived at after long and careful discussion.

Manchester Memoirs, Vol. liii. (1909), *No.* **12**.

XII. Differences in the Decay of the Radium Emanation.

By Professor E. RUTHERFORD, F.R.S.,
AND
Y. TUOMIKOSKI.

Received and read March 23rd, 1909.

Determinations of the rate of decay of activity of the radium emanation have been made by various methods by a number of observers. The activity has been found to decrease exponentially with the time with a period (*i.e.*, time taken to fall to half value), varying in different cases between 3·75 and 3·99 days.

Experiments were begun a few months ago by Mr. Tuomikoski to determine the decay of the radium emanation over a wide range of activity. For this purpose a large amount of emanation was enclosed in sealed tubes, and the decay of activity measured by the γ rays, using for the purpose an electroscope surrounded by lead. The rate of decay of the emanation has been found to be irregular, depending upon the treatment to which the emanation had been subjected. For example, a sample of emanation, purified by condensation with liquid air, commenced to decay for the first five days with an average period of 3·58 days. Between 5 and 20 days the average period was 3·75 days, while between 20 and 40 days the decay has been nearly exponential with a period of 3·85 days. Another preparation of emanation

was found to decay exponentially from the beginning with a period of 4·4 days. Similar differences have been observed in a number of experiments. These variations in period of decay must be ascribed to differences of quality of the emanation in the various cases.

As a result of a series of experiments, it has been found that samples of emanation which decay most rapidly are more easily absorbed in water and more easily condensed by liquid air than the more slowly decaying fractions. For example, if the radium emanation is allowed to stand over water for some hours, the part absorbed in the water decays more rapidly than the part unabsorbed. In a similar way on condensing the emanation, the part removed by pumping has a longer period than the part condensed.

We have been unable to find any evidence that radium produces two emanations, or that the products of transformation of the emanation of slow period are in any way different from those of the emanation of quick period.

The results indicate that the emanation is a non-homogeneous chemical substance. So far as our observations have gone, it appears probable that the physical and chemical properties of the emanation atoms vary to some extent with their life, *i.e.*, on the length of time after production before disintegration. It seems probable that the atoms of emanation undergo a progressive change in properties before disintegration. Further experiments are in progress to test the correctness of this point of view.

XIII. On the Moving Force of Terrestrial and Celestial Bodies in relation to the Attraction of Gravitation.

By Henry Wilde, D.Sc., D.C.L., F.R.S.

Received and read March 23rd, 1909.

1. In the course of a lecture which I delivered before the Society in 1902, "On the Evolution of the Mental Faculties in relation to some Fundamental Principles of Motion," prominence was given to the historic controversy respecting the measure of moving force of terrestrial bodies which has exercised the minds of distinguished men of science and learning for more than two centuries.

2. The proposition was enunciated by Descartes in his *Principia*,* "That when a part of matter is moved with double the quickness of another, and that other is twice the size of the former, there is just precisely as much motion, but no more, in the less body as in the greater." Forty years later Newton adopted in his *Principia* Descartes' definition of the quantity of motion in a moving body in substantially the same terms as follows:— "The quantity of motion is the measure of the same arising from the velocity and quantity of matter conjointly. The motion of the whole is the sum of the motion of all its parts; and therefore in a body double in quantity with equal velocity the motion is double; with twice the velocity it is quadruple." To make this definition more explicit, Newton states under his second law, "if any force generates a motion, a double force will generate double the motion, a triple force triple the motion, *whether that force be impressed altogether and at once, or gradually and successively.*

* "Principia Philosophiæ," Pars. 2, § XXXVI., 1643.

April 8th, 1909.

3. Although Galilei had long before demonstrated that the spaces described by heavy bodies from the beginning of their descent are as the squares of the times and also of the velocities acquired in falling through those spaces, yet the significance of this law in relation to the moving force of bodies was entirely overlooked until Leibnitz made the announcement that the force of a body in motion, by the free action of gravity, is as the square of the velocity. To this measure of moving force Leibnitz applied the term, *vis viva*, or living force.

4. The controversy which has since gathered round the question of the measure of moving force and still remains unsettled, forms a remarkable chapter in the history of the physical sciences. As might have been anticipated, *à priori* philosophers, mathematicians, metaphysicians, and men of letters, unskilled in experimental methods of interrogating nature, adopted the Cartesian measure of moving force. Of these may be mentioned, Maclaurin, Hutton, and Young; Locke, Kant, Schopenhauer, Voltaire, and other writers of more or less note up to the present epoch. Happily for the progress of science a number of natural philosophers, among whom Smeaton, Wollaston, Ewart, Dalton, Joule, and Fairbairn stand pre-eminent, have proved conclusively by various methods, that the true measure of the moving force of a body under the free action of gravity is as the square of the velocity.* Nevertheless, modern scholasticism has not yet pronounced decidedly in favour of the law, and the

* These results have been abundantly confirmed by my experiments with the gyroscope described in the lecture referred to, wherein it was shown (1) that four times the weight falling from the same height were required to generate a double velocity of the revolving disc; (2) that one unit of weight falling through four times the height also generates a double velocity of the disc; (3) that the moving force required to generate a double velocity of the disc is independent of the time of its application and is as the square of the velocity.—*Manchester Memoirs*, vol. 46, no. 10, 1902.

traditional error of Descartes and Newton still survives in manuals of elementary and advanced science, under the name of momentum, in contradiction of Newton's second law which expressly excludes the element of time in the measure of the quantity of motion in a body.

5. In the preface to his *Principia* Newton set forth with singular lucidity and ingenuousness, the dependence of the mathematical principles of natural philosophy upon experimental mechanics in their application to the motions of celestial bodies. It will therefore be obvious that the question, whether the quantity of motion in a planetary system is simply as the velocity, or as the square of the velocity is one of fundamental importance. So far as I know, no attempt has yet been made to deal with this problem, and no explication of astronomical science can be considered complete so long as it remains unsolved.

6. In order to demonstrate that the moving force by which the moon and other celestial bodies are maintained in their orbits is as the square of the velocity, it is postulated as general knowledge in physical astronomy :—

(*a*) That the equatorial circumference of the earth is 24,900 miles.

(*b*) That the versed sine of five miles (or more exactly, 4·936 miles) of the earth's circumference is 193 inches = 16 feet 1 inch.

(*c*) That a body at rest near the earth's surface falls perpendicularly through the versed sine of 4·936 miles of arc of the earth's circumference = 16 feet 1 inch during one second of time.

(*d*) That as versed sines are as the squares of their arcs, and the accelerative force of gravity increases in the same proportion, a body

projected horizontally near the earth's surface with a velocity 4·936 miles (26,062 feet) per second, would revolve round the earth continually without touching it.

(*c*) That $\frac{24900 \text{ miles}}{4{\cdot}936 \text{ miles}} = \frac{5044^{S}}{60^{S}} = 84{\cdot}07$ minutes = the time of revolution of a body round the earth with an angular velocity of 26,062 feet per second (*d*).

7. The mean distance of the moon according to modern astronomy, is 60·28 semi-diameters of the earth, and the time of its revolution in respect to the fixed stars, 27 days, 7 hours, 43 minutes = 39343 minutes. Now as the times and velocities of rotation are reciprocally equivalents of each other, we have $\frac{39343^{m}}{84^{m}{\cdot}07} = 468$ as the ratio of the orbital times or velocities of a body revolving round the circumference of the earth and the moon's orbit respectively. Therefore $468 \times 84{\cdot}07 = 39344^{m} = 27$ days, 7 hours, 44 minutes, for the time of the moon's orbital revolution.

8. Again, from the square of 468, as a velocity, divided by the moon's distance in semi-diameters of the earth we have $\frac{468^{2}}{60{\cdot}28} = 3634$, or reciprocally $\frac{1}{3634}$ the total moving force of a body revolving round the earth's circumference and the moon's orbit respectively, the numbers being the same as those deduced from the law of attraction of gravitation for the same distance.

9. As the radius of the moon's orbit is 60·28 semi-diameters of the earth, we have with the earth's radius in miles, $3964 \times 2 \times 60{\cdot}28 \times 3{\cdot}1416 = 1501370$ miles for the circumference of the moon's orbit. Dividing this by the time

of revolution in minutes we have $\frac{150137\text{0 miles}}{39344 \text{ min.}} = 38{\cdot}160$ miles per minute = 3358 feet per second for the moon's orbital velocity.

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10. That forces of any kind radiating from every point of a body in free space are inversely proportional to the square of the distance is a proposition requiring but little demonstration seeing that it flows directly from the geometry of space. It will be sufficient if I mention in this connexion the intensity of light which increases and diminishes in this same ratio, as is commonly demonstrated by photometers. Experimental mechanics were not sufficiently advanced in Newton's time to enable him to determine the ratios of the attractive and moving forces of celestial bodies, as there was apparently no physical connexion between such bodies, and it was chiefly from observation and his geometry that the law of attraction of gravitation as the inverse square of the distance was established.

11. The application of the law to the moon's orbit is the subject of the fourth proposition of the third book of the *Principia*, and is of so much importance in relation to my paper that I have thought it well to give an abstract of the text from Motte's classical translation. The linear quantities in the original are expressed in Paris feet, but are here given in English measure in accordance with modern usage :—

"Let us assume the mean distance of the moon to be 60 semi-diameters of the earth, and if we imagine the moon deprived of all motion to be let go, so as to descend towards the earth with the impulse of all that force by which it is retained in its orbit, it will, in the space of one

minute of time, describe in its fall 16 feet 1 inch. For the versed sine of that arc which the moon, in the space of one minute of time, would by its mean motion describe at the distance of 60 semi-diameters of the earth is nearly 16 feet 1 inch. Wherefore since that force in approaching to the earth in the reciprocal duplicate proportion of the distance, and, upon that account, at the surface of the earth 60×60 times greater than at the moon, a body in our regions falling with that force ought, in the space of one minute of time, to describe $60 \times 60 \times 16$ feet 1 inch. And with this very force we actually find that bodies here upon earth do really descend. And therefore the force by which the moon is retained in its orbit becomes, at the very surface of the earth, equal to the force of gravity which we observe in bodies there. And therefore the force by which the moon is retained in its orbit is that very same force which we commonly call gravity."

12. I have already demonstrated that the moon's orbital velocity is 38·160 miles per minute, and that a body would describe an arc of 4·936 miles of the earth's circumference in one second, during which time it would fall through the versed sine of that arc = 193 inches. Now as the versed sines of arcs of the same length are as the radii inversely from the centre, we have $\frac{193 \text{ inches}}{60{\cdot}28}$ = 3·21 inches as the versed sine of 4·936 miles of the moon's orbit. Again, as versed sines are as the squares of their arcs, we have $\frac{38{\cdot}160 \text{ miles}}{4{\cdot}936 \text{ miles}}\ 7{\cdot}73^2 \times 3{\cdot}21$, or nearly 16 feet 1 inch, as the versed sine of 38·160 miles through which the moon falls towards the earth during one minute of time in accordance with Newton's demonstration.

13. The assumption by Newton of the whole number

60 as the distance of the moon in semi-diameters of the earth in combination with the same even number in seconds and minutes of time greatly facilitated the demonstration of the law of the attraction of gravitation, the truth of which could at once be perceived by a simple mental calculation. Thus $60 \times 60 = 3600$ is the attractive force at the earth's surface, and reciprocally $\frac{1}{3600}$ at the distance of the moon's orbit. Now this same demonstration is equally applicable to the quantity of moving force of terrestrial bodies as well as at the distance of the moon's orbit. For as the moving force is as the square of the velocity, a body falling during one minute through a distance of 16 feet 1 inch at the moon's orbit, that is to say, with a velocity 60 times less than at the earth's surface, its moving force would be $60 \times 60 = 3600$ times less than that of a body falling the same distance during one second of time on the terrestrial globe. Therefore the moving force and the attraction of gravitation are alike inversely proportional to the square of the distance, and are correlated equally in amount to maintain and retain the moon in its orbit during the course of its revolution round the earth.

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14. The quantitative relations of the moving and attractive forces of the planetary bodies are set forth in the following new calculus of elements, wherein Mercury is taken as unity instead of the Earth, as in ordinary astronomical tables.

15. The masses of the bodies are taken as equal and require to be multiplied by the specific mass of each planet for the total force.

16. As the moving and attractive forces are

correlatively equal they are expressed by the same numbers and their reciprocals, Mercury = 1·000, and Neptune $= \frac{1}{6020} = 0{\cdot}000166$, as in the similar calculus of the moving and attractive forces of the moon during its orbital revolution.

17. The planetary distances in radii of that of Mercury may be taken as astronomically correct, as they are derived from the periodic times; but the numerical expression of them in miles is necessarily only a near approximation, from the fact that the value of the unit of distance has not yet been exactly determined. Accepting, provisionally, the unit distance of Mercury to be 35,860,000 miles, we have for the mean distance of the Earth from the Sun, $2{\cdot}583 \times 35{,}860{,}000 = 92{,}626{,}380$ miles, and of Neptune, $77{\cdot}59 \times 35{,}860{,}000 = 2{,}782{,}377{,}400$ miles. In like manner the intermediate planetary distances in miles may also be determined.

NEW TABLE OF ELEMENTS OF THE LUNAR AND PLANETARY ORBITS.

	Distances in Radii.		Periodic Times. Days.	Moving and Attractive Forces. Radii^2.	Reciprocals.
Mercury. . .	$1{\cdot}000^3$ = ... $\sqrt{1{\cdot}000}$ =	$1{\cdot}000 \times 87{\cdot}97$ =	87·970	1·000 =	1·00000
Venus. . . .	$1{\cdot}868^3$ = ... $\sqrt{6{\cdot}522}$ =	$2{\cdot}554 \times 87{\cdot}97$ =	224·700	3·489	0·28661
Earth	$2{\cdot}583^3$ = ... $\sqrt{17{\cdot}239}$ =	$4{\cdot}152 \times 87{\cdot}97$ =	365·256	6·671	0·14990
Mars	$3{\cdot}936^3$ = ... $\sqrt{60{\cdot}980}$ =	$7{\cdot}809 \times 87{\cdot}97$ =	686·980	15·492	0·06455
Ceres	$7{\cdot}148^3$ = ... $\sqrt{365{\cdot}200}$ =	$19{\cdot}110 \times 87{\cdot}97$ =	1681·400	51·094	0·01957
Jupiter . . .	$13{\cdot}437^3$ = . . . $\sqrt{2426{\cdot}000}$ =	$49{\cdot}260 \times 87{\cdot}97$ =	4332·580	180·633	0·00553
Saturn . . .	$24{\cdot}640^3$ = . . . $\sqrt{14957{\cdot}000}$ =	$122{\cdot}300 \times 87{\cdot}97$ =	10759·000	607·129	0·00165
Uranus . . .	$49{\cdot}550^3$ = . . $\sqrt{121661{\cdot}000}$ =	$348{\cdot}840 \times 87{\cdot}97$ =	30687·000	2455·202	0·00041
Neptune . .	$77{\cdot}590^3$ = . . $\sqrt{467142{\cdot}000}$ =	$683{\cdot}494 \times 87{\cdot}97$ =	60127·000	6020·208	0·00016
Moon	$60{\cdot}28^3$ = . . $\sqrt{219038{\cdot}000}$ =	$468{\cdot}000 \times 84{\cdot}07$ =	27·322	3634·000	0·00027

XIV. On the Occurrence and Distribution of some Alien Aquatic Plants in the Reddish Canal.

By F. E. Weiss, D.Sc., F.L.S.,
Professor of Botany in the University of Manchester,
AND
H. Murray,
Assistant Keeper in the Manchester Museum.

Read January 26th, 1909. Received for publication, March 9th, 1909.
With One Map.

Several interesting communications have been made to this Society during the last few years, by Mr. Charles Bailey,* and by Mr. G. A. Dunlop† of Warrington, on alien plants found in Lancashire. For the most part, the aliens described, were terrestrial plants, which owed their introduction to this country, partly to the disposal of refuse and ballast, and partly to the use of corn siftings for poultry food. There are, however, well known instances of the introduction into this country of alien pond and waterweeds, the most prolific of which, is the now ubiquitous American or Canadian Pondweed (*Elodea Canadensis*) which, growing with remarkable vigour, has in many cases completely filled up ponds and waterways,

* Bailey Charles. "On the Adventitious Vegetation of the Sandhills of St. Annes-on-the-Sea, North Lancashire (vice-county 60)." *Manchester Memoirs*, vol. 47, no. 2, 1902. "Further Notes on the Adventitious Vegetation of the Sandhills of St. Annes-on-the-Sea, North Lancashire (vice-county 60)." *Ibid.*, vol. 51, no. 11, 1907.

† Dunlop, G. A. "Alien plants of the Warrington District." *Manchester Memoirs*, vol. 52, no. 15, 1908.

and has greatly interfered with the fishing in some localities. One of the notable and interesting cases of the establishment of alien aquatics in the Manchester district, has been the occurrence of several plants from Southern Europe, in a portion of the Reddish Canal, where the temperature is more or less permanently raised by the inflow of heated water from several Cotton Mills along its banks. The two best known of these aliens, are *Naias graminea* (Del.) var *Delilei* (Magnus) and *Chara Braunii* (Gmel.), were first reported as occurring in a natural state in England, at the meeting of the British Association in Southport in 1883, and owe their discovery to Mr. John Whitehead of Dukinfield. An excellent account of *Naias graminea*, and of its occurrence in Lancashire, together with an attempt to settle the manner of its introduction into this country, was given by * Mr. Charles Bailey in the *Journal of Botany*, in 1884. *Naias graminea* is not a native European plant, though it has been found in some stations in the plains of Lombardy, where according to Italian botanists it has been introduced with East Indian Rice, which is cultivated in Northern Italy. Mr. Bailey, however, came to the conclusion that the seeds were not brought into Lancashire from these European stations, but probably with bales of Egyptian cotton, which is used in one of the mills, whence the seeds were transported with the refuse from the blowing and carding rooms into the canal. This is rendered all the more probable by the fact that the variety of *Naias graminea*, named *Delilei* by Dr. Magnus† occurs

* Charles Bailey. "Notes on the structure, the occurrence in Lancashire, and the source of origin of *Naias graminea* Del." *Journal of Botany*, vol 22, nos. 262 and 263, 1884.

† Magnus P. "Über eine besondere geographische Varietät der *Najas graminea* Del. und deren Auftreten in England." *Ber. der deutsch. Bot. Gesell.*, 1883.

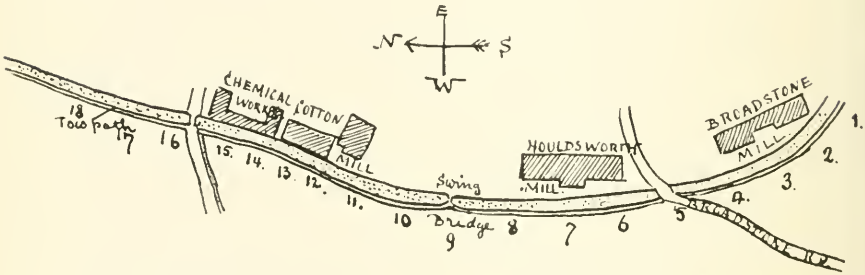
in the Nile Delta, and also by the fact that the accompanying form of *Chara Braunii*,* which occurs at Reddish is very near the form of that species which occurs in Northern Africa.

Shortly after my advent to Manchester in 1892, I visited this interesting locality with Mr. Charles Bailey, and we collected specimens of both these plants. I have since visited this locality on various occasions, and always found both plants present.

In December, 1908, being desirous of getting some fresh specimens of these two interesting aliens to show to the Botanical Survey Committee, on the occasion of its visit to Manchester, I was disappointed to find it impossible to obtain any specimens of *Naias graminea*, and I have been equally unsuccessful on my visit last week. Whether it has been unable to compete with the more luxuriant development of the Canadian pondweed, or whether the undoubtedly greater contamination of the canal with refuse and other suspended matter, has affected its growth or reproduction unfavourably, I cannot say, but it seems to me not unlikely that both factors have contributed to its disappearance, or at all events to a considerable reduction in the number of its plants, for it is still possible that it occurs in some reaches of the quarter of a mile along which it was formerly found. But though the filth on the bottom of the canal seems to have accumulated, and the surface of the water is in parts covered with a greasy film, vegetation is still fairly abundant, and most of the other plants mentioned by Mr. Bailey (*Potamogeton crispus*, *P. pusillus*, *Myriophyllum*, *Elodea* and *Chara Braunii*) are present, and in some places, fairly abundant. *Zannichellia* we have not been

* Groves H. and J. "Notes on the British Characeae." *Journal of Botany*, 1884.

able to find on our last two visits. The *Chara Braunii* (Gmel.) seems very evenly distributed along the warmer parts of the canal, and does not seem to have been affected by the deterioration of the water. It occurs quite plentifully in the middle of the canal opposite the new Broadstone Mill, and reaches from station 1 on the map, without interruption to 7. Beyond that point it disappears probably partly owing to the lower temperature and partly to the greater vigour and abundance of *Elodea* and other more hardy waterweeds. It reappears however, in stations 13 and 14, opposite other inflows of warm water from the furthest cotton mill.



PORTION OF MANCHESTER AND ASHTON-UNDER-LYNE CANAL.

Mixed with the *Chara* and the *Elodea*, one finds in the deeper water several small algae of which *Cladophora glomerata* is perhaps the most abundant, while *Pithophora* which is closely allied to *Cladophora*, with which genus it has sometimes been confused, is of more interest, being a freshwater alga of almost exclusively tropical distribution. It was observed growing on some living plants of *Naias graminea* which we sent by Mr. Charles Bailey to the British Museum, and was described by *Dr. Rendle and

* A. B. Rendle and W. West, Junr. "A New British Freshwater alga." *Journal of Botany*, vol. 37, 1899.

Mr. W. West in the *Journal of Botany*. It seemed to these authors to agree most closely with *Pithophora oedogonia*, a tropical South American species, a variety of which however, occurs in the Southern United States. The Reddish form is looked upon as another variety, and has been named var. *polyspora* (Rendle and West fils), on account of the greater number of its spores. No species of this genus has, as yet, been recorded from Egypt, or indeed from any part of Africa. The assumption therefore, as regards this alga, is that it may have been introduced with American Cotton. Its distribution in the canal indicates that it is more resistant than the other aliens to lower temperatures, as it extends uninterruptedly from station 1 to 18, and may indeed, extend far beyond the portion of the canal actually examined by us.

On working through the material collected on our visit in December, Mr. Murray discovered an alga not previously recorded from Reddish, or indeed from any locality in Britain. It is a small branching alga, of greenish blue colour, slightly red in reflected light, and which could easily be identified as belonging to the genus *Compsopogon*, Montagne. This genus, the only one in its family, occupies a somewhat indeterminate position among the algae, being generally regarded as nearly related to the Bangiaceae, a somewhat primitive or reduced family of the Red Algae or Rhodophyceae. Most members of the latter are marine, but there are a few freshwater forms of the Rhodophyceae, such as *Batrachospermum* the common Frog-spawn Alga, and *Lemanea*, both of which occur in our mountain streams. *Compsopogon* on the other hand, is entirely tropical and subtropical in its distribution, and its occurrence in the Reddish Canal, must clearly be attributed to the same causes that have

brought about the appearance of *Pithophora* and the other aliens. Its distribution in the Reddish Canal, is more restricted than that of *Chara Braunii*, and much more so than that of *Pithophora*. This may of course, be due to its more recent introduction, and this view might receive some support from the fact that it had not been previously observed. But it might easily have escaped notice among the *Pithophora* with which it is mixed, though, when once it had been observed, it could be readily picked out from the rest of the material. On the other hand the fact that it occurs only at the stations 3, 4, 5 and 6, at which the temperature was highest during our last visit, ranging from 73 to 75°F. is in favour of temperature being a limiting factor in the distribution of this alga. Wherever it was found, it was pretty abundant, arising as small unbranched filaments attached to *Pithophora*, and *Chara*, and to the leaves of *Elodea*, *Alisma*, *Potamogeton* and *Vallisneria*. Later on the filaments become branched, and ultimately the large axial cells become covered in by a layer of smaller cortical ones. Some of the latter have a denser aspect, and are evidently the sporangial cells. The escape of the large non-ciliate monospores, was not observed, but empty sporangia were noted, so the plant is evidently able to reproduce in the canal by spore formation, a fact which is further attested by the numerous small plants which have evidently arisen from spores. We propose to follow out the life history of this interesting alga, and hope that it may help to throw light upon a genus of which our knowledge is still very incomplete.

A comparison of the plant with specimens at the British Museum, shows that it agrees very closely, both in its macroscopic and microscopic structure with *Compsopogon leptocladus* of Montagne,* a species which has

* Montagne C. L. "Cryptogamia Guyanensis." *Ann. des Sci. Nat., Bot.*, (3), vol. 4, pp. 283—309, 1850.

so far only been found in Guiana. The only species recorded in Europe, is *C. Corinaldi* Menegh., which was once found near Pisa, but has apparently now disappeared.*

On our last two visits to the Reddish Canal, we were much interested to find patches of *Vallisneria spiralis* with its characteristic female flowers. This plant we had not observed before, possibly owing to the likeness of its leaves to those of young submerged plants of *Alisma*, which are common along the banks of the canal. I am told by Mr. Hardy, of the Manchester Museum, that the *Vallisneria* was planted in the canal nearly 40 years ago. Though planted between the swing bridge and the mill (that is, near station 9), it has spread now along the canal, and has established itself in several patches, all of which are in the warmest regions of the canal. Thus one clump was found near Broadstone Mill (station 4) to east of the inflow from that mill, and one to the west of the inflow (station 5). Two other patches occurred near the inflow from Reddish Mill (station 6 and 7), and a fifth and sixth ones at stations 12 and 13, that is, close to the inflow from the furthest mill. The temperature of the canal varied on the occasion of our last visit, from 39° to 76°F. at various points, and *Vallisneria* grew in water which, for the most part was over 70°F. It will be seen, therefore, that this plant has selected definite positions apparently, according to the warmth of the water.

In concluding we should like to acknowledge the help received from Mr. T. G. Osborn and Mr. W. Brierley in our preliminary survey of the alien vegetation of the Reddish Canal, which we hope to follow up more closely. At present we may say that the aliens so far noted, have

* De Toni J. B. "Sylloge Algarum." Patavia. 1889-1907.

established themselves more or less successfully in the canal in the following order :—

Pithophora oedogonia, stations 1 to 18 (inclusive).
Chara Braunii, 1 to 7, and 13 to 14.
Vallisneria spiralis, stations 4 to 7, 12 and 13.
Compsopogon sp., 4, 3 to 6 (inclusive).

Naias graminea has apparently disappeared, or is at all events, much reduced in amount.

Manchester Memoirs, Vol. liii. (1909), *No.* **15.**

XV. The Use of Wind by Migrating Birds.

By F. Stubbs.

(Communicated by Mr. T. A. Coward, F.Z.S.)

Received and read February 23rd, 1909.

Most modern observers think that birds when migrating, or even when moving short distances, fly against a head wind, or with a beam wind. Gätke ("Heligoland," *Eng. Trans.*, p. 27) believed that "to escape the disagreeable experience of having the wind blowing obliquely through their plumage from behind" birds turned their heads to the wind. Mr. Headley states (*British Birds*,* vol i., p. 121, 1907) that "if a bird flying with the wind only equals its velocity, he is part of the moving current, as the balloon is. The air does not resist, and consequently does not support him, but it assists gravitation. It would also ruffle his plumage." Mr. J. H. Gurney says without hesitation (*Zoologist*, 1888, p. 81) that "no one who has paid any attention to the subject can have failed to observe that the feathered visitants to this country will always, if possible, fly against the wind."

Anyone acquainted with the literature of ornithology will be able to add to these instances, but I am not aware of any record of accurate observations supporting this popular theory. Mr. W. E. Clarke's observations (*Rep. Brit. Ass., Liverpool*, 1896, p. 476) that "strong winds

*The title of the magazine *British Birds* is printed in italics. The titles of such completed works as Yarrell's "British Birds" are here given in inverted commas preceded by the author's name.

have a curious effect on the flight of Gulls, compelling them to move in a direction more or less directly heading the wind. Thus a strong westerly wind causes great numbers of Gulls to seek the estuaries and bays of our east coast. On the other hand, strong westerly winds will fill the estuaries and sea locks of the west coast with these birds. The lee side of islands is also sought under similar conditions of the wind," can be explained in another way. A few writers, while not explicitly discarding this "Head-wind Theory," have shown signs of leaning towards the contrary opinion. A foot-note in Yarrell's "British Birds," (4th *edit.*, vol. 3, p. 321) says: "It by no means follows that the direction of the wind with which the birds drop on the land is the same as that prevailing at a greater elevation, and this should be taken into consideration in estimating all records of the arrival of migrants." Stevenson's "Birds of Norfolk" (vol. 2, p. 273) contains a passage to much the same effect. It is strange that the late Professor Newton altogether ignored the matter in his comprehensive "Dictionary of Birds."

Let us for the moment assume that Gätke and others holding this "Head-wind Theory" are in the right. To the observer on the coast, the velocity of the wind must be at least about ten miles an hour. At an altitude of 500 feet, which is a very low elevation for the path of a migrating bird, the velocity would be perhaps double—say for example 20 miles an hour. A Goldcrest, a familiar migrant, desires to cross the North Sea to England, a distance of from 250 to 350 miles. We may call it for the present 300 miles, and allow the bird a velocity of 25 miles an hour. In a perfectly calm atmosphere the journey would occupy 12 hours. When the so-called favourable head-wind is blowing, that part of the earth's atmosphere lying over Western Europe is moving east-

wards at, say, 15 miles an hour—between force 2 and 3 of Fitzroy's scale: a moderate estimate for autumn. The bird has thus to make its journey in a supporting medium that is moving at the same time in an opposite direction. In one hour it will have flown 25 miles through that body of air, but during the same time the aerial mass has moved 15 miles eastwards. Between two points on the earth's surface the bird will have travelled no more than 10 miles. At this rate the journey will take 30 hours. It should be quite evident that no bird can make any headway against a wind with a greater velocity than its own speed of flight.

I am unable to refer to any definite statement by one of those who hold this head or beam wind theory, but the general opinion seems to be that when a bird flies head to wind the air rushes past it at a total velocity which is that of the wind plus the velocity of the bird. Of course, this would be quite true in the case of a steamer, a cyclist, a pedestrian, or even a swimming bird. But it is absurd to assume that it is so in the case of a flying bird, or even—the parallel may be useful to some minds—in the case of a swimmer in a strongly flowing current; the bird and the swimmer are wholly in a moving supporting medium. (I might point out here that it is not safe to study avian flight by the aid of sailing ships. A ship is supported by the water but propelled by the air. The bird is supported by the air and propelled by its wings.) Mr. Headley's remark that the wind "impinges on their backs and so tends to drive them downwards" I fail to understand. The same author, in his "Structure and Life of Birds" (p. 185), compares the flying bird to a skater on thin ice, passing rapidly from one portion of supporting medium to another, none of which is sufficient to support it if the bird or the skater remained stationary. This simile is not, I think, justifiable.

Most of us, especially outdoor observers, form conceptions of the wind which are altogether wrong. We are apt to look upon it as a seething current, and we pity the poor birds that are carried about by it. The substitution of the word *air* for *wind* in all matters relating to the flight and migration of birds would prevent a great deal of misunderstanding. There can be no doubt that if a bird cannot find shelter it will be more comfortable on the wing than on the ground during the progress of a storm. Mr. T. A. Coward tells me that during a storm of unusual violence the ducks on a Cheshire mere sprang into the air, heads to wind, *and flew at full speed in the teeth of the gale*, thereby keeping their places over the middle of the mere, to the surface of which they dropped as soon as the sudden storm was over. Their reason for this manœuvre was, obviously, to be out of the danger of being between two conflicting elements, the stationary water and the moving air. In the air they made no progress against the wind, but had they flown with it, a few minutes would have sufficed to place many miles between them and the water they were so loth to leave.* This, I think, is the explanation of the conduct of the Gulls mentioned by Mr. Clarke. The bird, then, can fly about in any direction in this wind, but it must be remembered that the whole body of air is moving in some definite direction which may or may not coincide with that in which the bird happens to be flying. If the wind blows from east to west at 50 miles an hour at an altitude of 5,000 feet—and migration is carried on at far greater heights than this—and the bird is capable of flying through the air at 50 miles an hour, its net velocity, between points on the earth's surface, if it flies from east to west, would be 100

* I saw these methods adopted by the Gulls and Hooded Crows during the blizzard which raged on the East Coast on March 6th, 1909.

miles an hour; in a contrary direction—with a "Head-wind"—it would have made no progress at all, like the ducks over the mere. If merely flying lazily round in a 50 feet circle it would have travelled in one hour 50 miles which is the velocity of the medium supporting it.

I must now refer to Mr. W. E. Clarke's very important report of the Committee (Prof. A. Newton, Messrs. J. Cordeaux, J. A. Harrie-Brown, W. E. Clarke, R. M. Barrington, and Rev. E. P. Knubley) appointed by the British Association to investigate the subject of migration. It appears in full in the *Report* of the Liverpool meeting, 1896, pp. 451—477. It is here stated that meteorological conditions have been closely studied in relation to migration. Under the heading of *Winds*, occurs the statement that "The importance attached to winds in connection with bird migration, has hitherto been much overestimated by popular writers, and their influence, such as it is, misunderstood. The conclusions to be drawn from a careful study of the subject are (1) that the *direction* of the wind has no influence whatever *as an incentive to migration*; but that (2) its *force* is certainly an *important* factor, inasmuch as it may make migration an impossibility, arrest, to a greater or lesser degree its progress, or even blow birds out of their courses. It is, however, a fact that particular winds almost invariably prevail during the great autumnal movements, and these have hitherto been considered by some as the direct incentives to such migrations. Such is not the case, and it may at once be stated that these supposed favourable breezes are simply another direct result of the pressure distribution favourable to the movements."

This last statement detracts very considerably from the value of those parts of the *Report* that treat of meteorological conditions. The breezes are *not* in this instance the

result of the pressure distribution, but the very converse is the case. These parts are still further weakened by the separation of the portions headed *Meteorological* (*i.e.* Barometric conditions) and *Winds*. The author seems to ignore the close connection between the two. Another passage may be given here (p. 476) "There is really no reason why westerly (west, north-west, or south-west) winds, not too strong of course, should not, *other things being equal*, be in every way as suitable for migratory movements [westwards across the North Sea] as those varying between such divergent points as north-east to south." Then follows the passage I have already quoted on the flight of Gulls. From what I have already explained it will be seen that I cannot in the least accept the suggestion.

Winds do not, in this part of Europe, move in straight lines. They come to us, especially in autumn, in a curved line from the Equator over the Atlantic, in a series of huge eddies or "cyclones," laden with a mass of water vapour, and, I now suggest, bearing at migration times a horde of birds. A cloud to-day lying over Norway may be trailing to-morrow over Manchester, and the next day over the south of France. I believe that birds habitually make use of these cyclones as a means of travelling from one part of their range to another under the most favourable conditions for the exercise of flight. It is clear to me that a bird, unless it possessed power of flight sufficient to make it somewhat independent of wind, would have great difficulty in struggling across the concentric currents of a cyclone. This aspect of the wind seems never to have been studied by the holders of the "Head-wind" or "Beam-wind" theory, but I have recently come across a passage in Mr. Abel Chapman's "Wild Norway" (p. 339) that leaves little doubt that he has

been led towards this point of view, and it is unfortunate that so excellent an observer has not thought fit to go deeper into the subject. As it is, his remarks are apparently merely tentative. I give the passage in full. "Except by aid derived from the operation of physical laws, the nature and extent of which are unknown to me, and by taking advantage of 'Trade-wind' circulations in the upper air, I believe that migration is impossible for short-winged forms of sedentary habit . . . . But that aid, and those advantages, may facilitate, and perhaps vastly accelerate, a process which is otherwise impossible."

I suggest that the bird takes up its position in the nearest part of the rim of the cyclone to its point of departure, and flies in the same direction as the wind until that portion of the aerial medium that supports and carries it arrives over that part of the world, or the nearest point, which the bird desires to reach. I will not run the risk of obscuring my point by dealing with anti-cyclones; the general process would be much the same. The ascending currents of cyclones must be mentioned, for a bird supported in one would soon be carried to a great height, from which it might start a long "glide" on open wings, supported by the upward current in the manner of a Gull flying above a cliff.

Mr. Clarke's actual observations support my theory (*t.c.* p. 470). He points out that favourable conditions for autumnal migration are "the presence of a large anti-cyclone over Scandinavia, and cyclonic conditions to the westward of the British area, with a low pressure centre off the west coast of Ireland." There is a strong outward and downward current from above the core of an anti-cyclone, and this would be most useful to birds crossing the North Sea in autumn. This was the state of affairs on September 23rd, 1908, when a large migration was noticed on the

coast of Norfolk (*cf.* Richards *Brit. Birds*, vol. 2, p. 200). The barometer stood at 30·28 over Sweden, and at 29·8 over Ireland and south-west England. On the 25th the depression had reached the North Sea, and on this day we are informed that the migration considerably decreased. The occurrence of such continental birds as Red-breasted Flycatchers (*Muscicapa parva*), Blue-throats (*Cyanecula suecica*), and Yellow-browed Warblers (*Phylloscopus superciliosus*) on these days would be due to the prevailing southerly winds on the western edge of the anti-cyclone carrying the birds out of their proper courses. For an example of the effect of cyclonic movements, I may refer to Mr. Clarke's invaluable observations at Fair Isle (*Annals Scott.N.H.*, 1908, pp. 72-75, *fide Brit. Birds*, vol. 1., p. 982). The appearance at this island of the Yellow-browed Warbler and the Siberian Chiff-chaff (*P. tristis*), both birds of Northern Europe, coincides with a period of strongly marked cyclones over the western parts of the continent from October 20th to 24th, 1807. I have not been able to consult any barometric readings for October 13th, 1891, but on this date there was a very heavy migration of enormous numbers of Goldcrests, Robins, Buzzards, Owls, Blackbirds, and many other birds. *The wind was east, blowing more than half a gale.* These observations were made on the coast of Yorkshire, and published in *Natural Science*, vol. 1, p. 779, in a review that has internal evidence of being the work of the late J. Cordeaux. I should expect to find that on the date given above there was a deep depression over France or Holland. Of course, these meteorological charts have been used before, but apparently without a knowledge of the connection between wind and cyclones, and with a wrong idea of the position of a bird flying in a moving body of air.

I may add that great caution is necessary in using the data derived from the exact experiments made on the velocity of Pigeons, Partridges, and Pheasants (*cf.* Newton, *t.c.*, p. 566), and other estimates derived from the performances of Homing Pigeons. Such birds are non-migratory, and obviously handicapped in long journeys. The Pigeon (*Columba livia*) is not a good long-distance traveller. A study of the facts and figures of pigeon flying will prove this.

In conclusion, I must express my indebtedness to Mr. T. A. Coward. Without his help and encouragement this paper could never have been written.

General Meeting, January 12th, 1909.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

Mr. HERMANN HENRY HOFFERT, D.Sc. (Lond.), Associate of the Royal School of Mines, His Majesty's Inspector of Schools, *Lime Grove*, *Brooklands*, *Sale*, was elected an ordinary member of the Society.

Ordinary Meeting, January 12th, 1909.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

The PRESIDENT expressed his warm congratulations and those of his fellow members to Professor E. RUTHERFORD, F.R.S., on the signal honour recently conferred on him by the award to him of the Nobel Prize for his researches on Radio-activity. Professor Rutherford, who was present, briefly responded, and said the Society was known and honoured in Norway for its association with the name and work of Dalton.

Dr. F. W. GAMBLE, F.R.S., Secretary of the Society, read a paper entitled "**The Influence of Light on the Colouration of certain Marine Animals** (*Hippolyte*, **Wrasses**)."

The author gave an account of his work on the colour-physiology of *Hippolyte* (the Aesop-prawn), and of one of the common British Wrasses (*Crenilabrus melops*).

Hippolyte is a variably coloured prawn, each colour-variety agreeing closely with the tint of the weed on which it is found,

and upon which it feeds. Previous experiments made jointly by the author and Professor Keeble have shown that this remarkable sympathetic colouration is in all probability not inherited—*i.e.*, the colour-varieties do not necessarily breed true, but that the harmonious motley exhibited by this varying species is the outcome of a very special colour adaptation acquired by each individual, and that the colouration is controlled largely by the colour of the weed at the time when the young prawn settles down upon it, after a brief free-living larval existence.

The results of more recent researches by the author on this subject have shown that the amount of red pigment in the larva varies, in all races but the green one, with that in the parent. The more there is of it in the parent, the more highly coloured is the offspring. Green parents, however, gave rise to three kinds of broods: (1) highly coloured ones like those of brown parents, (2) pale ones, and (3) a mixed brood, containing coloured to colourless in the proportion of 3 : 1. This result tends to show that green *Hippolyte* are derived (1) from brown individuals that have been transformed into green, after migrating from brown to green weed; (2) from green individuals that have remained on their weed, and (3) from a cross between these kinds.

Further experimental results were obtained on the prolonged influence of light on the colouration of this animal both when white light was reflected on the young *Hippolyte* from a porcelain dish, and also when the young animals were kept in coloured light (red or green). In the former case the existing pigments (red and yellow) gradually disappeared from the greater portion of the animal, and at length, after a month's interval, only one strip of pigment remained, but this formed a dense screen around the nervous system. This screen is probably of considerable physiological significance, as it is found in many of the lower crustacea, and also in many worms.

The coloured light experiments yielded an unexpected result, namely, a complementary colour to that of the light employed. Thus, under the influence of green light for a month, *Hippolyte*

lost its yellow pigment, and became brilliantly scarlet: while under red light it became green. In both cases the animal at starting was of a transparent and almost colourless appearance. The value of this complementary colour production (which does not appear to have been recognised in animals previously) upon the problem of the colouration of *Hippolyte* was briefly discussed.

General Meeting, January 26th, 1909.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

Mr. GEORGE PERCY VARLEY, M.Sc. (Vic.), and Mr. JOHN HENRY WOLFENDEN, B.Sc. (Lond.), A.R.C.S. (Lond.), Assistant Masters in the Municipal Secondary School, Manchester, Mr. SIDNEY RUSS, B.Sc. (Lond.), Demonstrator in Physics in the University of Manchester, and Mr. H. E. SCHMITZ, M.A., B.Sc., of the Manchester Grammar School, were elected ordinary members of the Society.

Ordinary Meeting, January 26th, 1909.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

The PRESIDENT stated that on March 9th, the occasion of the Wilde Lecture, the Lecturer, Dr. H. BRERETON BAKER, F.R.S., would be entertained at a dinner in his honour at the Midland Hotel, and the price of the tickets would be 7s. 6d., not including wine, the same as last year.

Professor F. E. WEISS, D.Sc., F.L.S., read a paper, written in conjunction with Mr. H. MURRAY, entitled "**On the Occurrence and Distribution of some Alien Aquatic Plants in the Reddish Canal.**"

The following specimens of the plants referred to in the paper, collected by the authors in a portion of the Canal, were exhibited:—*Naias graminea*, *Chara Braunii*, and *Vallisneria spiralis*; a small green fresh water alga *Pithophora* and an interesting red alga *Compsopogon*, not previously recorded for Britain.

Mr. T. G. B. OSBORN, B.Sc., read a paper entitled, "**The Dowels of some Egyptian Coffins of the XIIth Dynasty.**"

Mr. J. WILFRID JACKSON, F.G.S., read a paper, communicated by Dr. W. E. HOYLE, F.R.S.E., entitled, "**On the Diatomaceous Deposit of the Lower Bann Valley, N. Ireland, and Prehistoric Implements found therein.**"

The three papers are printed in the *Memoirs*.

General Meeting, February 9th, 1909.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

Mr. FREDERICK HOWLES, M.Sc., Analytical and Research Chemist, and Mr. CHARLES WEIZMANN, Ph.D., D.Sc., Senior Lecturer in Chemistry in the Manchester University, were elected ordinary members of the Society.

Ordinary Meeting, February 9th, 1909.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables. The following were among the recent

accessions to the Society's Library :—"*Second Report on Research Work...on the Negative Results of the Examination of...Raw Water...for...Typhoid Bacillus*," by A. C. Houston (fol., London, 1908), presented by the Metropolitan Water Board ; "*National Antarctic Expedition, 1901-04, Album of Photographs and Sketches*," and "*Album of Panoramas*," 2 vols. (fol , London, 1908), and "*Reports to the Evolution Committee. Report IV.*," by W. Bateson and others (8vo., London, 1908), presented by the Royal Society of London ; "*Legeeringen van Tin en Lood. Proefschrift*," door P. N. Degens (8vo., Dordrecht, 1908), "*Der niederländische Boden u. die Ablagerungen des Rheines u. d. Maas*," door P. Tesch (8vo., n. pl., 1908), presented by the Technische Hoogeschool te Delft ; "*Capture and Escape*," by J. A. Kellogg (8vo., n. pl., 1908), "*The Vicksburg Campaign*," by W. F. Vilas (8vo., n. pl., 1908), presented by the Wisconsin History Commission ; "*Summary Report on Explorations in Nova Scotia, 1907*," by H. Fletcher (8vo., Ottawa, 1908), "*The Geology and Mineral Resources of New Brunswick*," by R. W. Ells (8vo., Ottawa, 1907), presented by the Geological Survey of Canada ; "*Codex Diplomaticus Lusatiae superioris III.*," Hft. 4, von R. Jecht (8vo, Görlitz, 1908), presented by the Oberlausitzische Gesellschaft Wissenschaften, Görlitz ; "*Reseña historica de los Ferrocarriles del Peru*," por F. C. y Laurent (4to., Lima, 1908), presented by the Cuerpo de Ingenieros Civiles del Lima ; and "*Catalogue of the MSS. in the Library of the Hunterian Museum, University of Glasgow*," by J. Young and P. H. Aitken (fol., Glasgow, 1908), presented by the University of Glasgow.

Mr. W. H. TODD and Mr. C. GORDON HEWITT, M.Sc., were nominated auditors of the Society's Accounts for the session 1908-09.

At this point Mr. FRANCIS JONES, M.Sc., F.R.S.E., occupied the Chair.

The PRESIDENT exhibited some of the apparatus with which he, in conjunction with his research students, had been repeating

experiments on the ignition point of gases by the method of adiabatic compression suggested by Professor Nernst.

In the first experiments tried the compression was effected in a strong glass tube, and photographs of the explosion were taken on a rapidly moving film. The photographs showed that the ignition was not set up instantaneously throughout the whole mass of compressed gas, but began at one point, which might be varied according to the velocity of the piston. In a mixture of hydrogen and oxygen 'detonation' is very rapidly set up, but not instantaneously.

The later experiments were made in a steel tube, a window being inserted near the lower end of the tube so as to observe the flame produced.

Ordinary Meeting, February 23rd, 1909.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

THE PRESIDENT made reference to the recent purchase by the Society, of a chronometer watch belonging to the late Dr. J. P. JOULE, which the Council had resolved to place in one of the Society's rooms, as a memorial of a distinguished past President, whose work on the mechanical equivalent of heat, created a landmark in the history of science.

Mr. T. THORP, F.R.A.S., described a simple method of silvering transparent grating replicas, whether plane or mounted on curved surfaces. The process is a modification of the quicksilver and tinfoil method used for ordinary mirrors before the wet silvering process had been discovered.

Mr. Thorp stated that when required as a "silvered" grating, it was necessary that the surface should be very perfect, any inequality in such a reflecting surface being $-\frac{2\mu}{\mu - 1}$ or 4μ, where the refractive index is 1·5, more prejudicial than in a transmission grating.

Mr. THOMAS KAY exhibited a fossil coral, stated on the authority of Dr. Hoyle, of the Manchester Museum, to be a specimen of the *Syringopora ramulosa*, a carboniferous fossil, and some spherical concretions of clay, which were found in the sandhill of Hempshaw Lane, in Stockport.

Its place in these sand hillocks, which were formerly dunes by prehistoric lakes and rivers associated with the geological fault which stretches from Bredbury to beyond Poynton, may be due to its having been carried down from the great Derbyshire carboniferous plateau by one of its earliest streams. The specimen has been silicified, whether by deposition of silica on the carbonate of lime, or by the replacement of the latter by the silica, was not certain.

Professor F. E. WEISS read a paper entitled "**A Preliminary Account of the Submerged Vegetation of Lake Windermere as affecting the Feeding Grounds of the Fish.**"

Mr. F. STUBBS read a paper, communicated by Mr. T. A. Coward, F.Z.S., entitled "**The Use of Wind by Migrating Birds.**"

The two papers are printed in the *Memoirs*.

Special Meeting, March 9th, 1909.

The President, Professor H. B. DIXON, M.A., F.R.S., in the Chair.

The Wilde Lecture, on "**The Influence of Moisture on Chemical Change,**" was delivered by H. BRERETON BAKER, Esq., D.Sc., F.R.S., Lee's Reader in Chemistry in the University of Oxford.

General Meeting, March 23rd, 1909.

Professor A. SCHUSTER, Sc.D., F.R.S., in the Chair.

Mr. W. W. HALDANE GEE, A.M.I.E.E., B.Sc., M.Sc. Tech., Professor of Pure and Applied Physics, Manchester School of Technology, was elected an ordinary member of the Society.

Ordinary Meeting, March 23rd, 1909.

Professor A. SCHUSTER, Sc.D, F.R.S., in the Chair.

The thanks of the members were voted to the donors of the books upon the tables, and also to Mr. Francis Nicholson, F.Z.S., for presenting to the Society's Library the following volumes:—"Nicholson's Journal," vols, 1—5, 1778—1802; "Gilbert's Annalen der Physik," vols. 61—72, 1819—1822; "Studies in Anatomy from the Anatomical Department of the Owens College," vols. 1, 2, 1891, 1900, "Studies from the Physiological Laboratory of Owens College," vol. 1, 1891, "Handbook of the Manchester Meeting of the British Association," 1887, and "Excursions of the British Association, Manchester," 1887.

Mr. D. M. S. WATSON, B.Sc., who represented the Society at the Jubilee Celebration of the Geological Society of Glasgow, on January 28th, 1909, gave a brief account of the Proceedings on that occasion.

Mr. C. E. STROMEYER, M.Inst.C.E., exhibited some pieces of mild steel of which one had been made very brittle by contact with a caustic soda solution of a density of about 100° Twaddle, whilst the other, through having been suspended in a cast iron vessel in which caustic soda was being concentrated beyond 100° Twaddle, had lost about $\frac{3}{16}$ths of its diameter in 340 hours.

Dr. HENRY WILDE, F.R.S., read a paper entitled "**On the Moving Force of Terrestrial and Celestial Bodies in relation to the Attraction of Gravitation.**" The paper is printed in the *Memoirs*.

Mr. ALFRED HOLT, Jr., M.A., read a paper entitled "**The action of Hydrogen on Sodium.**" The paper will be printed in the *Memoirs*.

Professor E. RUTHERFORD, F.R.S., read a paper written in conjunction with Mr. V. TUOMIKOSKI, entitled "**Differences in the Decay of the Radium Emanation.**" The paper is printed in the *Memoirs*.

Ordinary Meeting, April 6th, 1909.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., Vice-President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables. The following were among the recent accessions to the Society's Library:—"*Report on the Northampton Mineral Field*" (8vo., Perth, 1908), "*Report on the Kanowna Mines*" (8vo., Perth, 1908), and "*Report on the Mines of the Yilgarn Goldfield*" (8vo., Perth, 1908), all three by A. Montgomery, presented by the Agent General for Western Australia; "*The Darwin-Wallace Celebration held . . . 1st July, 1908*" (8vo., London, 1908), presented by the Linnean Society of London; "*Physiological and Medical Observations among the Indians of S.W. United States and Northern Mexico*," by A. Hrdlička (4to., Washington, 1908), presented by the Bureau of American Ethnology; "*The Centenary of the Geological Society of London*" (8vo., London, 1909), presented by the Geological Society; "*Handbook of the Manchester Meeting of the British Association*" (16mo., Manchester, 1887), and "*Excursions, Manchester Meeting of the British Association*" (16mo., Manchester, 1887), "*Nicholson's Journal*," vols. 1—5

(4to., London, 1797-1802), "*Gilbert's Annalen der Physik*," N.F., 1—12 (8vo., Leipzig, 1819-1822), "*Studies in Anatomy from the Anatomical Department of the Owens College*," vols. 1—2 (8vo., Manchester, 1891, 1900), and "*Studies from the Physiological Laboratory of Owens College*," vol. 1 (8vo., Manchester, 1891), presented by Mr. Francis Nicholson; "*Swedish Explorations in Spitzbergen, 1758—1908*," by A. G. Nathorst and others (8vo., Stockholm, 1909), presented by the Kungl. Universitetets i Uppsala Bibliotek; "*Anatomie du Corselet et Histolyse des Muscles Vibrateurs, après le Vol Nuptial, chez la Reine de la fourmi* (Lasius niger)," Texte et Planches, par Ch. Janet, 2 vols. (8vo., Limoges, 1907), presented by the author; "*Magnetical, Meteorological, and Seismological Observations made at the Government Observatory, Bombay and Alibag . . . 1902-1905*," by N. A. F. Moos (fol., Bombay, 1908), presented by the Governor-General in Council, India; and "*Comptes Rendus des Séances de la 1re et 2me Réunions de la Commission Permanente de l'Association Internationale de Sismologie.. 1906-1907*," 2 vols. (fol., Budapest, 1906, 1907), presented by Professor A. Schuster, F.R.S.

Mr. Thomas Thorp, F.R.A.S., presented to the Society a silvered concave grating which he had produced by the method described by him at the meeting held on February 23rd, 1909.

Professor E. Knecht, Ph.D., in a preliminary communication on the hydrolysis of gun cotton, stated that, by heating the hexanitrate of cellulose in water contained in a sealed tube to 190° C., he had caused it to pass completely into solution.

Mr. C. E. Stromeyer, M.Inst.C.E., mentioned that he had found that although the nitrogen contained in some samples of steel, analysed for that element, did not improve the general quality of the steel, it certainly had a very powerful effect on its tenacity; and he suggested that the difficulties which had hitherto been experienced in harmonising the best results obtained with steels from different works were due to nitrogen, which had not been previously determined for this purpose.

Mr. R. L. TAYLOR, F.C.S., F.I.C., read a paper entitled, "**On some Colour Demonstrations of the Dissociating Action of Water.**"

Mr. HENRY SIDEBOTTOM read a paper entitled "**Report on the Recent Foraminifera from the Coast of the Island of Delos (Grecian Archipelago). Part VI.**" **(Conclusion.)**

Examples of *Polytrema miniaceum*, Linné sp., *Truncatulina variabilis*, d'Orbigny, and a decorated form of *Rotalia beccarii*, Linné, were shown under the microscope, and drawings of numerous other species were exhibited.

Mr. GEORGE HICKLING, B.Sc., read a paper entitled, "**On Permian Foot-prints.**"

The three papers will be printed in the *Memoirs*.

Manchester Memoirs, Vol. liii. (1909), *No.* **16**.

THE WILDE LECTURE.

XVI. On the Influence of Moisture on Chemical Change in Gases.

By H. Brereton Baker, M.A., D.Sc., F.R.S.

Delivered March 9th, 1909.

Thirty years ago, Prof. H. B. Dixon investigated the behaviour of carbon monoxide and oxygen when they were dried as completely as possible, and he discovered

CORRIGENDUM.

"Manchester Memoirs" vol. 53, No. **18**, page 3, line 8 from the bottom, *read* sulphocyanide *for* salicylate.

myself and others. It has been shewn that hydrogen and chlorine can be exposed to light without explosion, ammonia and hydrogen chloride mixed without union, sulphur trioxide can be crystallized on lime, ammonium chloride and mercurous chloride give undissociated vapours, hydrogen and oxygen can be exposed to a red

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Thirty years ago, Prof. H. B. Dixon investigated the behaviour of carbon monoxide and oxygen when they were dried as completely as possible, and he discovered that under these circumstances electric sparks caused no explosion. Some years before Wanklyn had discovered that purified chlorine did not act on sodium, but he did not identify the impurity, now known to be a trace of water, which causes the vigorous action which takes place under ordinary circumstances.

In 1882 Cowper investigated the action of dried chlorine on several metals, and found that the removal of moisture in many cases inhibited the reaction.

In the following year, working in Prof. Dixon's laboratory at Balliol College, I found that purified carbon could be heated to redness in dried oxygen, and that sulphur and phosphorus could be distilled in the same gas without burning. In the investigations which followed some twenty-five simple reactions have been tried by myself and others. It has been shewn that hydrogen and chlorine can be exposed to light without explosion, ammonia and hydrogen chloride mixed without union, sulphur trioxide can be crystallized on lime, ammonium chloride and mercurous chloride give undissociated vapours, hydrogen and oxygen can be exposed to a red

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heat without explosion, and lastly in 1907 my wife and I obtained nitrogen trioxide as an undissociated gas for the first time by carefully drying the liquid, and evaporating into a dried atmosphere.

The amount of water required to bring about these chemical actions is extremely small. Mere passing of a gas through long columns of phosphorus pentoxide is insufficient to prevent chemical action, and this treatment, according to the determinations of Prof. E. W. Morley, leaves only 3 mg. of water in 1,000,000 litres of the gas. For extreme dryness to be attained prolonged contact of phosphorus pentoxide is necessary. Of the reactions which have been tried with the utmost attention to purity of the substances, only a few, the combustion of carbon bisulphide, cyanogen, and some hydrocarbons in oxygen appear to be unaffected by the presence of small traces of moisture.

Many explanations have been attempted of the influence of moisture on chemical action. Dr. Armstrong suggested, during the discussion on my first paper at the Chemical Society in 1884, that all chemical actions were electrolytic in character, and that in ordinary reactions in gases the water vapour, impure as it would be, served as electrolyte. I believed in 1902 that I had obtained evidence in favour of his view, because on heating a mixture of very pure hydrogen and oxygen not completely dried, water was produced, doubtless very pure, but no explosion resulted. Prof. Dixon has since pointed out that the want of explosiveness in the wet mixture may have been due to the gases having been diluted by the steam formed and in presence of a neutral gas no explosion would be expected.

Sir J. J. Thomson in 1893 showed that if the combination of atoms in a molecule is electrical in its nature,

the presence of liquid drops of water, or drops of any liquid of high specific inductive capacity, would be sufficient to cause a loosening of the tie between the atoms, and this might result in chemical combination of the partially freed atoms to form new molecules. He showed in the same paper (*Phil. Mag.*, 36, 321) that drying a gas very completely stopped the passage of a current of 1,200 volts. In the same year I was able in the same way to prevent the passage of discharge from an induction coil, a discharge which would traverse a spark gap of three times the distance in undried gas.

Shortly after the discovery of Röntgen rays it was found that they would ionize a gas through which they passed. At the time it was thought that this ionization was similar to that taking place in electrolysis. If this were so the rays would probably cause chemical union to take place even in a dried gas, and accordingly Prof. Dixon and I undertook some experiments on the subject which were published in a joint paper (*Chem. Soc. Jour.*, 1896). The results were negative, no chemical action could be detected. Since that time the ionization of gases has been shown to be of quite a different nature. The negative ion has been shown to be a particle of the mass of $\frac{1}{1000}$th that of the hydrogen atom; the positive ion is the residue, but whether it is the residue of an atom or of a molecule seems to be still uncertain. Since the ionization of gases is different from that in electrolysis the retention of this term is much to be deprecated.

In order to illustrate the possibility of positive ions being charged atoms, and not molecules from which an electron had been split off, I devised a new experiment. It is known that mercury vapour in its ordinary state contains atoms only. It occurred to me to try if the charged ions in the mercury vapour lamp had any

increased chemical activity. Accordingly, after running such a lamp, containing specially purified mercury, the current was cut off, and shortly afterwards oxygen was admitted. The surface of the metal was found to be covered with red oxide. The temperature of the lamp is less than 150°, and at this temperature there is, under ordinary circumstances, no chemical action between mercury and oxygen.

In order to test further the question as to whether the ionization of molecules, as distinguished from atoms, can bring about chemical change, I have investigated the action of radium bromide on very pure and dry hydrogen and oxygen. The gases were sealed up with some radium bromide contained in an open silica tube. The containing vessel was provided with a vacuum gauge, by means of which the combination of $\frac{1}{3000}$th part of the gases could be easily detected. No action whatever was observed, although the substances were left in contact for two months. A further experiment showed that, as was to be expected, very dry air is readily ionized by radium. Two more tubes were then set up, similar to the first, containing mixtures of carbon monoxide and oxygen, one very dry, and the other containing traces of moisture, and although the radium bromide has been in contact with them for more than two months not the slightest contraction can be observed. In these cases therefore ionization produces no chemical change.*

There is, however, a possibility that ionization may bring about a chemical action in a mixture of gases which

* Madame Curie believed that radium bromide produced ozone in the air in which it is sealed up. The evidence for this statement is that a smell resembling ozone is observed on opening such sealed tubes. I have opened several such tubes which have been sealed up for a year or more, but I have only noticed a smell of bromine, which of course when faint resembles that of ozone.

is under conditions which are nearly, but not quite, suitable for chemical action to take place. The gaseous mixtures mentioned only combine, even when moist, at a red heat. Since the experiments were done at 20°, they only show that ionization does not produce chemical action in gases which are otherwise unable to combine.

There remained the possibility that if gases were just on the point of combining, increasing the ionization might accelerate the rate of action. I sought for a case of simple chemical union which would proceed at a manageable temperature, and at a rate which could be measured. Of those tried, the reaction between hydrogen and nitrous oxide was found to be the most suitable. The gases used were as pure as possible, but dried only by passing through phosphorus pentoxide tubes. They were found to combine with great uniformity when heated in clean Jena glass tubes to 530°. An electric resistance furnace was used, consisting of a wide silica tube which formed the heated chamber. It is known that many substances when heated ionize a gas ; lime is fairly efficient, thoria more so, and, of course, radium bromide most of all. In the first experiment two tubes of the same Jena glass, containing the hydrogen and nitrous oxide mixture, were heated side by side. One contained some lime, and in order to make the conditions as similar as possible, an equal quantity of powdered Jena glass was introduced into the other. As soon as the requisite temperature was reached, the action proceeded rapidly in the tube containing lime, the rate in the first five minutes being five times the rate of combination in the tube containing only powdered glass. After 15 minutes the second tube had caught up the first, and the rates of union were equal up to the completion of the action. With thoria the effect was still more marked, the rate increasing to twenty times the rate in the tube

containing the glass. Finally about 2 mg. of radium bromide was heated in the mixture of gases. As soon as the combining temperature was reached, the gases in the radium bromide tube exploded.

From these three experiments it is seen that as the amount of ionization was increased, there was a rapid increase in chemical action.

The next experiment tried, illustrates one way in which the ionization of a gas may bring about chemical change.

Hydrogen sulphide and sulphur dioxide can be mixed at the ordinary temperature in presence of traces of moisture, but in presence of liquid water, decomposition takes place into sulphur and water. The gases were dried before mixing by calcium chloride, which leaves about 4 mg. of water vapour per litre in the gas. After mixing, a small open silica tube containing about 2 mg. of dried radium bromide was introduced. After six hours no apparent change had taken place in the gas ; there was no deposit of sulphur on the sides of the jar, and it seemed at first as if no action had been produced. On opening the jar, however, an inrush of air was noticed, and the contents were almost odourless. On heating the radium tube a large quantity of water was driven off, and a copious sublimate of sulphur was seen. The whole of the gaseous contents of the jar had condensed in the small tube containing the radium bromide. The explanation of this action of radium bromide is probably simple. Water vapour condenses on the ions emitted, liquid drops are formed, and in them the chemical action takes place.*

* I have invariably noticed that water collects in tubes containing radium preparations exposed to undried air. The salts are not at all deliquescent, the crystals appearing quite sharp-edged under the microscope. I found that 10 mg. of radium bromide exposed to an atmosphere saturated at 0° for two days caused a deposition of water on its surface weighing 1·5 mg.

Is this explanation to be applied to the experiment with hydrogen and nitrous oxide? Can ionization of gas containing a mere trace of moisture cause deposition of this moisture in a form approaching that of a liquid? Prof. Townsend has very recently published an account of some remarkable experiments, in which he has shown that there is a very marked decrease in the mobility of negative ions in the presence of an amount of water vapour represented by a pressure of $\frac{1}{10}$th mm. The air, in his experiments, was ionized by Röntgen rays, but it is known that all gases are to some extent ionized, and it is possible that it is these ions, causing the deposition of water, which bring about chemical action, according to the theory of Sir J. J. Thomson, mentioned above.

I have found that if thoria is heated in hydrogen and nitrous oxide, dried over phosphorus pentoxide for a fortnight, no action at all is apparent when the tube is heated for five minutes to 530°. Hence ionization without water is ineffective in producing chemical action. Experiments are in progress to determine the question whether, if the spontaneous ionization of a gas is removed by an electric field, chemical action will be prevented even in the presence of water, but they are not sufficiently advanced to justify their publication.

Some experiments have been made upon the influence of metallic conductors on chemical change. Such sub-substances should, if Sir J. J. Thomson's theory is true, be even more efficient than drops of liquid having a high specific inductive capacity. Dixon and Lowe (*Chem. Soc. Jour.*, 1885, 571) showed that platinum brought about complete union between dried carbon monoxide and oxygen by continued heating, and the Rev. P. J. Kirkby has shown that hydrogen and oxygen at low pressure behave similarly. I have never been able to heat

hydrogen and oxygen in contact with platinum without causing explosion in the dried gases. A thin silver wire can, however, be melted in the mixture without causing explosion.

Mr. J. C. Thomson has recently done some experiments for me on the hydrogen sulphide and sulphur dioxide mixture. He finds that liquid alcohol and liquid sulphur dioxide (both having high specific inductive capacity) can bring about the decomposition in the mixture, while carbon tetrachloride, whose specific inductive capacity is low is inert. Also metallic aluminium and metallic mercury are apparently unable to affect the change.

XVII. The Action of Hydrogen on Sodium.

By Alfred Holt, Junr., M.A.

Received and read March 23rd, 1909.

Some time ago the author, while preparing some specimens of sodium hydride according to the method described by Moissan (*Comptes rendus*, vol. 134, p. 71), noticed certain features in the reaction of hydrogen with molten sodium which seemed to throw light on the relation of the hydride NaH with the compound Na_2H described by Troost and Hautefeuille (*Comptes rendus*, vol. 78, p. 807).

Many experiments were performed, of which the following present points of interest:—

1. A piece of pure, oil-free sodium was heated in a glass tube filled with hydrogen and standing over mercury. The metal was first heated for five days at 270° C. The bright metallic surface was then found to be covered with a white film of hydride, but none was sublimed on the glass. The volume of hydrogen absorbed was extremely small, not greater than that required to form the film of hydride. More prolonged heating at the same temperature did not perceptibly increase the volume of hydrogen absorbed by or combined with the metal. It is clear from this that at 270° C. the absorption of gas is small and is accounted for by the formation of the film of hydride.

2. Some sodium was heated in a current of hydrogen to about 400° C., at which temperature the hydride was subliming on the cooler portion of the tube. The sodium

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was then allowed to cool. Almost at once it became covered with a layer of hydride.

When cool it was reheated in the current of hydrogen. The white film of hydride round each globule of molten metal remained unaltered until about 370° C., when it disappeared, only to reappear on the cooler parts of the tube.

3. Some of the pure crystalline hydride (free from sodium) was heated in a current of hydrogen. It decomposed almost completely at a temperature below that at which it begins to sublime. The sodium arising from its decomposition became at once covered with a film of hydride, and at about 370° C. sublimation of the hydride began as in the previous experiments.

From this experiment, it appears that the hydride decomposes at a lower temperature when heated alone than when it is present as a film on the surface of molten sodium.

4. Some sodium was heated in a current of hydrogen, as in the previous experiments, until the hydride was subliming. It was then allowed to cool as rapidly as possible. When cold the sodium was analysed. The volume of hydrogen which it gave when treated with absolute alcohol was only slightly in excess of that which would result from an equal weight of pure sodium. As in this experiment the metal was heated to about 400° C., the amount of hydride dissolved in the sodium at this temperature cannot be very large.

5. A piece of sodium was heated in hydrogen in a vessel standing over mercury. At a temperature of about 450° C. the metal began to volatilise and attack the glass, but the absorption of hydrogen was extremely small, and there was no visible sublimate of hydride.

Now Moissan has shown that when sodium is heated to temperatures between 340° C. and 430° C. some hydride must be dissolved in the molten metal, since by the action of liquid ammonia (in which sodium is soluble) at −40°C., a residue remains which consists of nearly pure hydride. Troost and Hautefeuille from their observations, concluded that sodium when heated to 380° C. for a long time absorbed a volume of hydrogen consistent with the formation of a compound of composition Na_2H but that this compound began to dissociate about 300° C., the amount of dissociation rising rapidly with the temperature, till at 421° C. the tension of the hydrogen in the compound is 760 m.m. Hence, at this temperature, none of the compound is formed unless the hydrogen in which the sodium is heated has a pressure greater than that of the atmosphere.

It appears quite possible to co-ordinate the formation of this supposed hydride Na_2H of Troost and Hautefeuille with the known compound NaH prepared by Moissan.

When sodium is heated in a current of hydrogen at atmospheric pressure combination begins at 270° C., the hydride NaH being formed.

Most of this dissolves in the excess of sodium, forming a solution which may be conveniently regarded as sodium dissolved in sodium hydride (or NaH.Na). The addition of sodium to the hydride NaH will reduce its vapour tension, and hence none of it sublimes.

As the temperature rises the combination of the sodium with the hydrogen becomes more rapid, and the sodium dissolves more of the sodium-sodium hydride solution, the ratio of sodium to the hydride decreasing. But as the ratio decreases, the vapour tension of the hydride becomes greater, until at length it begins to sublime.

At the same time the solution NaH.Na dissociates more and more rapidly as the temperature rises.

About 380° C., the NaH.Na dissolved in the sodium is very largely dissociated, and at about this temperature the compound NaH begins to sublime.

This would explain experiment (4), for at the temperature to which the sodium was heated, very little of the dissolved hydride would remain undissociated. Troost and Hautefeuille failed to obtain the compound NaH since they heated their hydrogenised sodium in a closed vessel in order to determine the dissociation, whereas in Moissan's experiments the vapour of the hydride was condensed at the moment of its formation, and so removed from the equilibrium of H, Na hydrides. It would appear to be an analogous case to the dissociation of $CaCO_3$. Very little CO_2 or CaO is obtained unless one of the decomposition products is removed as fast as it is formed.

The formation of an easily dissociating compound Na_2H or NaH.Na as described by Troost and Hautefeuille is quite consistent with the sublimation of the compound NaH.

The finest crystals of the hydride (NaH) were obtained when the glass tube in which they were formed was about one inch internal diameter, and when the sodium was heated to the lowest temperature at which the hydride would sublime. The current of hydrogen should be at rather more than atmospheric pressure, as otherwise the crystals of hydride are found to be mixed with particles of metallic sodium.

The reactions of the compound have been studied in detail by Moissan, and the author has also repeated most of them. The action of a concentrated solution of hydrochloric acid produces a somewhat curious result. If a mass of the hydride is dropped into a test tube containing

a few drops of the strong acid, it catches fire and burns while falling through the moist gas above the liquid. The moment it touches the acid solution a violent decomposition, accompanied by a bright flash and a sharp report, takes place, while fine strings of sodium chloride crystals hang down in the acid liquid from the point at which the hydride touched it. The only other reaction which presents points of interest is with absolute alcohol. The hydrogen of the hydride seems to be given off entirely at the moment of contact with the liquid, as there is an immediate hissing and evolution of gas while the alcohol becomes warm, after which small globules and filaments of sodium swim about and disappear more gradually.

The other reactions will be found in the paper by Moissan to which reference has already been made.

The University, Manchester.

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XVIII. On some Colour Demonstrations of the Dissociating Action of Water.

By R. L. Taylor, F.I.C.

(Received and read April 6th, 1909.)

It is now almost universally recognised that the Theory of Ionic Dissociation affords the most satisfactory explanation of many otherwise inexplicable phenomena which accompany the solution of most acids, bases, and salts in water. For example, there are a considerable number of remarkable facts connected with the colours of various solutions of salts in water, which find the most reasonable explanation in this theory.

Thus it was long ago shown by Ostwald that the colours of dilute solutions of all permanganates were the same, no matter what the bases were. This is exactly what one would expect from the theory. All permanganates when in dilute solution are almost completely dissociated, and the negative ion is always MnO_4, which is a purple coloured ion. The colour of a dilute solution of a permanganate, then, is always the colour of the MnO_4 ion, and is therefore always the same. Similarly, the colour of the negative ion of chromates (CrO_4) is yellow, and therefore dilute solutions of chromates all have the same colour, no matter what the bases are, unless they are coloured as well. The blue colour of solutions of copper salts also is recognised as due to the positive copper ion. Copper chloride, however, both solid and in strong solution, is green, and copper bromide is dark brown,—almost black. These are the colours of the *compounds*; but when they are diluted with water they both turn blue;—they

both dissociate, and both yield the same copper ion, which is blue.

The above examples are all well known, but they are all connected with salts which dissociate when in solution yielding coloured ions. But we know a number of compounds which are themselves highly coloured, and are soluble in water, but which can be made from colourless, or almost colourless, materials. For example, ferric sulphocyanide is a compound with a deep blood-red colour, which is produced when a solution of a sulphocyanide (colourless) is added to a solution of a ferric salt (which when dilute has a pale yellow colour). The compound is very soluble in water. According to the theory, what ought to happen if this highly coloured compound is diluted with much water? If it dissociates, its ions are all but colourless, so that the blood-red colour ought to disappear. This is exactly what does occur. If some of the deep red liquid is poured, a little at a time, into a considerable bulk of water (one or two litres), it is very striking to notice the complete disappearance of the colour of the first portions added, and the really considerable amount which has to be added to produce a permanent red colouration in the water.

If an amount of the coloured liquid, just insufficient to produce a permanent red colouration, has been added to a considerable volume of water, it is interesting to note that the red colour appears on the addition of *either* solution of potassium sulphocyanide, or ferric chloride. The existence of the red compound depends on the concentration of the ions $\ddot{F}e$ and (CNS'), and if the concentration of either of these ions in the solution is increased, some of the red compound is formed.

The red compounds ferric acetate and ferric formate, when diluted with water, behave in a similar way to the

sulphocyanide, but, as their colours are not nearly so intense, the effect of dilution is not so striking. Ferric salicylate, which has a deep purple colour, behaves on diluting with water almost in the same way as the sulphocyanide, although the latter appears to dissociate somewhat more readily.

The colour of a solution of ferric salicylate is not very unlike that of a solution of potassium permanganate, and this enables us to see the remarkable difference in the effect of diluting the two solutions. (Diluting a solution of a permanganate will, of course, increase *its* dissociation ; but here the negative *ion* is coloured. In the other cases there can be no colour unless some of the undissociated compound is present.) If we take a solution of potassium permanganate $\left(\text{say about } \frac{N}{20}\right)$, two or three drops of it will impart a perceptible purple colouration to half a litre of water. If, on the other hand, we prepare a solution of ferric salicylate, which has about the same colour intensity as the permanganate, seven or eight cubic centimetres of it are required to produce a perceptible purple colouration in the same amount of water. It is not so easy to compare the colour intensity of ferric salicylate with that of the permanganate, but it is possible to prepare solutions of the two which have approximately the same colour intensity, and in this case the difference in the amounts of the two solutions which are required to produce a perceptible colouration in the same quantity of water, is even greater than in the case of the permanganate and the ferric salicylate.

XIX. A Modification of the Beckmann Apparatus by which Constant Readings are obtained in determining the Boiling Points of Aqueous Solutions.

By Professor EDMUND KNECHT, Ph.D.,

AND

J. P. BATEY, M.Sc.Tech.

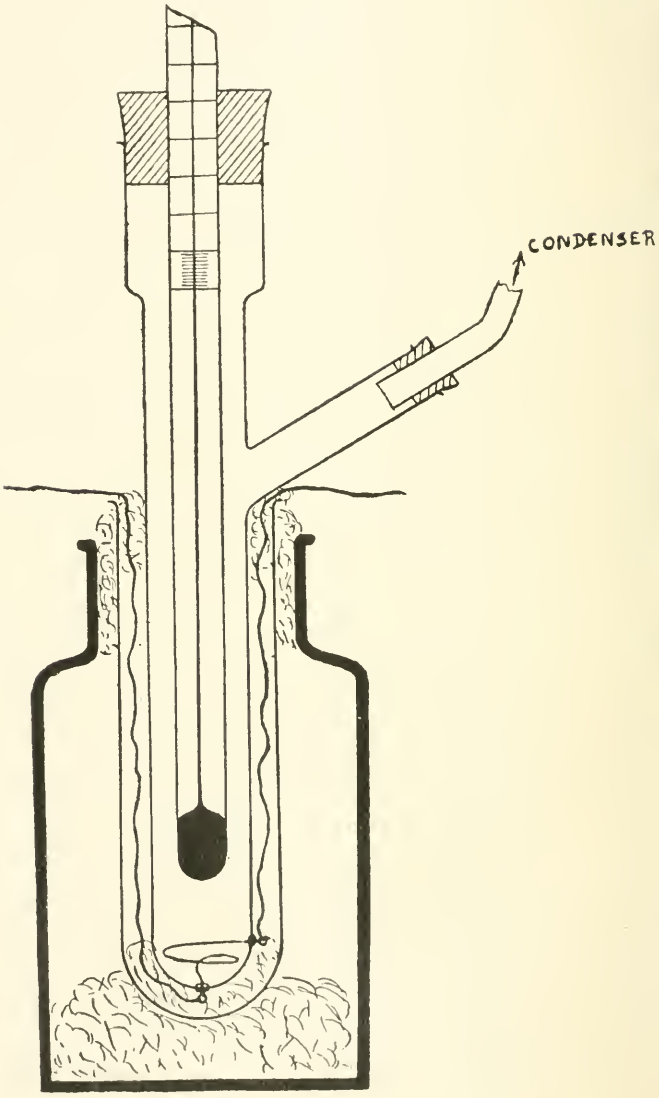
Read May 4th, 1909. Received for publication May 18th, 1909.

In the course of a research into the condition of certain dyes in aqueous solution, we desired to make ebullioscopic determinations of their molecular weights by determining the elevation which they produced in the boiling point of water. Owing to the complex nature and sparing solubility of these substances, it was only possible to obtain a very small rise in the boiling point, and it was found that with the types of Beckmann apparatus at our disposal it was not possible to obtain a sufficiently regular boiling point for our purpose. This we supposed was due to superheating effects caused by the cohesion of the liquid on the glass walls of the boiling vessel. To avoid this we were led to try an electric heating method in which the heat is supplied by a platinum wire, in direct contact with the solution.

A tube was made with a platinum heating coil inside, while somewhat thicker wires, fused through the glass, served for making the connections.

When in use the apparatus rested in an outer cylindrical glass jacket which itself rested in a wide-mouthed bottle, packed at the bottom and round the neck with

cotton wool. (*See diagram.*) It was found that with this arrangement the boiling point of the solution remained constant to 0·001° C. We subsequently found



that electrical heating had been used before for this purpose. S. L. Bigelow (*Amer. Chem. Journ.*, vol. 22, p. 280, 1899) first used the method, and demonstrated its usefulness. Later the subject was fully discussed by E. Beckmann in his paper: "Fehler der ebullioskopischen Verfahren und Versuche zu deren Beseitigung." (*Zeit. Phys. Chem.*, vol. 63, p. 177, 1908.)

Both these experimentors state that the method is not applicable for use with aqueous solutions.

Thus, Bigelow says:—"Electric heating is not applicable for use with water solutions, for difficulties due to electrolysis would surely be encountered."

Beckmann found that a solution of potassium bromide was instantly turned brown when a current of 2 amperes was passed through the heating coil; and this, even when alternating current was used.

We repeated the experiment with KBr in our apparatus with a direct current of 7 amperes, and not a trace of bromine was liberated. In view of this fact we were led to compare the physical constants of Bigelow's and Beckmann's apparatus with those of our own.

Bigelow and Beckmann both used a heating coil of 5 ohms resistance. The current used by Beckmann to produce the necessary heating effect was:—

$1\frac{1}{2}$ amperes for low boiling solvents.

2 „ high „ „

The drop in potential across the coil would therefore be $7\frac{1}{2}$ to 10 volts.

In our apparatus the resistance of the heating coil at 100°C. was 0·47 ohms.

Current used 6·5 amperes.

Drop in potential across wire 3 volts only.

Evidently the electrolysis will depend on the drop in potential across the heating coil, and when this is

reduced to a certain point (for KCl about 2½ volts) the amount of electrolysis will be theoretically nil.*

The following experiments were done with a view to ascertaining how much electrolysis actually does take place.

A 10 per cent. solution of KCl was put in the apparatus and a current of 7 amperes passed for ¾ hour.

The liquid was then titrated for chlorate by means of titanous chloride, and it was found that only 0·2 per cent. of the KCl had been converted into $KClO_3$.

A 10 per cent. solution of KI was treated with 7 amperes for ½ hour. The liquid was then titrated for iodine by means of thiosulphate (after acidifying).

Found—Iodine (free and as iodate) 0·5 per cent. on the weight of KI.

A 10 per cent. solution of KI treated with 7½ amperes for ¾ hour.

Found—1·0 per cent. iodine (free and as iodate).

A 2 per cent. solution of crystal scarlet was treated for 30 minutes with 6½ amperes, and was then titrated with titanous chloride.

Found—1·5 per cent. of the dye destroyed.

In the above experiments the currents used are slightly greater, and the time much longer than would be the case in carrying out a determination.

It is evident, therefore, that by using a heating coil of low resistance the amount of electrolysis which takes place is negligible.

Measurements of the molecular elevations produced, have been made with several electrolytes and non-electro-

* This was shown to be the case in another apparatus in which the resistance of the heating coil at 100° was 0·32 ohms. With a current of 7½ amps. this would correspond to 2·2 volts. With a 10% solution of KCl, and boiling for half-an-hour under these conditions, no chlorate was produced. In this apparatus the electrolysis of KI was less than in the other one.

	A.	B.	C.	Kg.	W.Bz.	S.	
KCl	0·2715	0·250°	9·26	9·24	—	—	
	0·736	0·672	9·17	9·13	9·33	9·03	
	1·105	1·018	9·24	9·22	9·25	9·19	
				Kg.	L	S.	H.Bz.
KNO_3	0·280	0·248°	8·77	8·99	—	—	9·27
	0·577	0·502	8·70	8·65		9·02	8·79
	0·830	0·730	8·80	8·69	8·34	8·65	8·54
				Kg.	W.Bz.	S.	H.Bz.
NaCl	0·0564	0·059	10·8	—	—	10·5	10·8
	0·389	0·394	10·13	—	9·11	—	10·35
	0·442	0·439	9·94	9·14	9·51	9·3	10·35
	0·733	0·734	10·02	9·39	—	—	10·28
	1·390	1·440	10·38	10·13	9·67	10·04	10 56
				L.	Bn.	F.Kr.	
CH_3COONa	0·0298	0·022	(8·57)	—	—	8·5	
	0·1703	0·167	9·57	—	9·07	—	
	0·3301	0·318	9·65	—	—	8·57	
	0·1281	0·131	10·22	—	9·34	—	
	0·2742	0·280	10·20	—	—	—	
	0·4157	0·416	9·98	—	—	—	
	0·586	0·565	9·91	9·28	8·94	9·29	
				Kg.	L.	Bn.	
Cane Sugar...	0·0977	0·049	4·97	—	—	4·86	
	0·1950	0·106	5·26	4·94	5·10	4·86	
				L.	Bn.		
Urea	0·0922	0·037	(3·9)	—	—		
	0·317	0·134	4·22	—	4·32		
	0·658	0·280	4·26	—	4·27		
	0·989	0·444	4·52	4·74	4·35		
	1·522	0·682	4·50	4·56	4·27		

lytes, and in the following table the results obtained are compared with those of other observers.

Column A gives the strength of the solution in gram molecules per litre. B is the observed rise in temperature, while C is the molecular elevation of the boiling point.

$$C = 10\frac{B}{A}.$$

In the remaining columns are given values for C obtained by different observers at approximately the same concentration of solution.

It will thus be seen that by employing a heating coil with suitable resistance, internal electrical heating can be used for aqueous solutions.

It possesses the one great advantage over the usual method of heating, in that absolutely constant readings are obtained, without any special precautions.

Where the necessary current and appliances are available, the electrical heating is more convenient than gas heating.

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XX. On the Tent-building Habits of the Ant *Lasius niger* Linn. in Japan.

By Marie C. Stopes, Ph.D., D.Sc.,

and

C. Gordon Hewitt

(*The University, Manchester*).

(*Received and read May 4th, 1909*).

During the recent visit of one of us (M. C. S.) to Japan, the tent-building habits of the common brown or black garden ant *Lasius niger* Linn., which forms tents of a character and shape hitherto undescribed, were observed. The tents were found on *Ilex integra*, which was growing on a low hill near the sea at Hayama, a small bathing village within fifty miles of Tokyo.

L. niger is one of the commonest species of ants in England. Prof. W. M. Wheeler, who kindly confirmed the identification of the specimens collected from these tents, says that he is unable to distinguish these and other specimens previously received from Japan from the common European form. In England they usually construct subterranean galleries and frequently cultivate Aphides for the sake of the honey-like fluid, the so-called "Honey dew" which appears to be formed in the alimentary canal, and is used by the ants for food. It has been stated that during the winter they take the eggs of the Aphides into their nests as a protection against frost.

In the colonies of the Japanese ants about to be described, the form of the tents and the covered passages which

connect the same with the underground nests of the ants can be seen best from the figure. This shows the stump of a stem (*A*) of the *Ilex* which had been cut down, and in consequence was provided with several leafy shoots near the ground. *B* is the base of the adjacent uncut stem, about 30ft. high, which had no leafy shoots near the ground, nor did it show any traces of ant habitation.

The tents were of the detritus type. In their construction the ants had used the sand from the soil in the neighbourhood, which was of a blackish colour; mixed with it were numerous white fragments of broken shell. Very little cementing material appeared to have been employed, since in the dry condition the tents were broken by the slightest pressure.

The form of a complete tent can be seen at *c* in the figure. It will be observed that the whole twig and its leaves, with the exceptions of the ends of the leaves, are enclosed in the detritus tent. The whole, therefore, forms a cylindrical, sausage-shaped mass, from which the tips or unrolled edges of a few of the leaves (*l.*) project, but most of the leaves are completely enclosed in the sandy covering, through which run galleries which were found to be swarming with ants.

The tents communicate with the subterranean nests by means of covered galleries (*g.g.*) which were built of detritus and wound round the tree trunk in a curved manner. By means of these galleries the ants travel from the ground to the interior of the tents where the aphides are housed.

At the tips of the enclosed branches the young leaves (*b.*) can be seen projecting as they have recently been unfolded from the bud. The ants soon turn their attentions to these new leaves, which are treated like the rest in a peculiar manner. They appear to bite the lower side of

the midrib, and this results in the curling of the leaves ventrally, the upper side of the leaf being outwards, as seen at *br.*, where the young leaves have begun to be inrolled. On the left-hand side of the figure a twig is seen, which has not yet been enclosed by a detritus casing. Here the leaves are more tightly rolled up as they grow older, and the space formed by the inrolled portion is enclosed with sand. The ants are found in these inrolled leaves. When fresh, the leaves appeared to be living, as no doubt was the case, otherwise the aphides, for whose protection the tents are constructed, would be unable to subsist on them. They had, however, no trace of green colour, but were instead a livid purple. The leaves which project from the tent, as *lt.*, had green tips. A normal untouched leaf is shown at *n*.

Unfortunately, as the observations were made during a few days vacation, no reagents or instruments were available, and no field experiments could be made. The specimens collected were fixed in the local wine *saké*, which proved to be an excellent preservative, as its percentage of alcohol is very high.

In their anatomy the dwarfed and rolled leaves show no fundamental difference from the normal ones, but all the tissues, particularly the vascular tissue and palisade cells, are much less differentiated. For example, one layer only of short palisade cells in them represents the elongated double layer that is found in the normal leaf. Along the under side of the midrib are several smaller wounds, which remain as brown scars of destroyed tissue, as seen under the microscope; these are probably produced by the biting action of the ants' mandibles, and cause the rolling of the leaves. Brown scars also occur along the edge of the leaf, which in some instances is slightly toothed.

The cause of the curling and dwarfing of the leaves does not seem to be an effect of the aphides, or at any rate of the aphides alone, but appears to be the result of direct manipulation by the ants. Several plants of the same species in the neighbourhood bore twigs with ants on the backs of leaves which were beginning to curl, but which seemed entirely free from aphides.

Prof. W. M. Wheeler in a letter to one of us (C. G. H.) says that this species and its varieties in America are in the habit of building tents over plant lice and mealy-bugs, and in his interesting paper (1906) on the habits of the tent-building ant *Crematogaster lineolata* Say, he refers to the same habit of *L. niger*. The common American form *L. niger* var. *americana* occasionally builds detritus tents around the stems of plants.

Huber describes the tent-building habit of *L. niger* in his classic work (1810). Small spherical tents were found on the spurge, and, as in the case of the tents of the Japanese ants, the stem of the spurge formed the axis of the structure. The latter was of the carton type, being constructed of wood. In these shelters the ants kept the plant-lice, which were thus protected from their enemies and also from the rain and sun.

Forel (1874) has also described the tents which several European species of *Lasius* construct. One form, *L. brunneus*, constructs galleries made of detritus over large bark aphides. Some species of *Myrmica* cover the aphides with earthen cells which communicate with the nest by means of covered galleries.

There is no doubt that this habit of building detritus and carton tents has developed for no other purpose than that of protecting the various species of aphides which are kept by the ants for the sake of their honey-like secretions. By the construction of such "cowsheds," as

they might be termed, the aphides are able to continue sucking the juices of the plant and at the same time they are not only protected from their enemies but also from alien ants. The protection from cold is also important, as Brandes (1894) has found that aphides are most active during the warmer part of the day, so that in keeping them warm the ants would also be obtaining a larger supply of the secretion from them. In addition to these explanations of the tent-building habits of ants, Wheeler (*l.c.*) also suggests that the tents may be to prevent the escape of the aphides to other plants or other parts of the same plant.

The evolution of the forms of the tents which are found in the different genera of tent-building ants may have started with the small earthen cell covering a few aphides: this may have been constructed either on the stem or by filling the space formed by the inrolling of certain of the leaves. Further enlargement and elaboration would lead to the formation of a spherical or cylindrical tent having the stem as axis, and finally, to secure for themselves the greatest comfort and convenience, the ants would connect these tents either with the earth or with their subterranean nests by means of covered passages.

The phenomenon does not appear to be common in Japan, for though travelling widely over the country, the observer noted these galleries and tents only in one district. Simple nest building ants inhabiting trees were reported as being widely distributed, but the type of structure here described does not seem to have been noted hitherto, and may possibly be a local peculiarity of the ants.

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EXPLANATION OF PLATE.

Ilex integra bearing tents of *Lasius niger L.*

A. Stump cut off near to the ground, leafy twigs sprouting from it.

b. bud of leaves projecting from a 'tent.' *br.* new leaves beginning to be rolled. *c.* tent. *g.g.* covered galleries of detritus. *lt.* tips of leaves projecting from the tent. *n.* normal leaf. *s.* leaves which are inrolled, the space underneath being enclosed in detritus.

B. Base of a stem which reached a height of 30 feet: it had no branches near to the ground and no ants were found upon it.

(The figure was drawn from the living specimen *in situ* by M. C. S.)

b
br
c
n.
s
lt
g.
A
B
X 1/2

Manchester Memoirs, *Vol. liii.* (1909), *No.* **21**.

59.21.2 (4)

XXI. "Report on the Recent Foraminifera from the Coast of the Island of Delos (Grecian Archipelago)." Part VI. (Conclusion.)

By Henry Sidebottom.

(Received and read April 6th, 1909.)

Planorbulina, d'Orbigny.

*Planorbulina mediterranensis, d'Orbigny. (Pl. 1, Figs. 1-3).

Planorbulina vulgaris, d'Orbigny ('39), p. 134, pl. 2, fig. 30.

P. vulgaris (d'Orb.), Williamson ('58), p. 57, pl. 5, figs. 119, 120.

P. mediterranensis (d'Orb.), Brady ('84), p. 656, pl. 92, figs. 1—3.

P. mediterranensis (d'Orb.), Silvestri ('98), p. 286, pl. 6 (11), figs. 4-7.

P. mediterranensis (d'Orb.), Flint ('99), p. 328, pl. 72, fig. 6.

This form occurs in three varieties. The first,* Fig. 1, Pl. 1, is often of irregular growth, with inflated chambers, and has the peripheral edge rounded. The second,* Fig. 2, Pl. 1, has the peripheral edge sharp, and the under surface quite flat. The third variety, Fig. 3, Pl. 1, has also the peripheral edge sharp, or slightly blunted, but the central portion of the free surface is covered with irregular chambers. The planorbuline arrangement of the segments on the underside (superior) is quite distinct, as also are the apertures, though small. The first and second varieties are frequent, and the third not quite so frequent.

* The asterisk denotes that this species occurs at Palermo.

Planorbulina acervalis, Brady. (Pl. 1, Fig. 4.)

Planorbulina acervalis, Brady ('84), p. 657, pl. 92, fig. 4.

P. acervalis (Brady), Brady, Parker and Jones ('88), p. 227, pl. 46, fig. 11.

P. acervalis (Brady), Flint ('99), p. 328, pl. 72, fig. 7.

Brady ('84) reports this species from the Red Sea and other places. It resembles certain forms of *Gypsina*, but is distinguished from them by its peripheral apertures. Rather rare.

Truncatulina, d'Orbigny.

***Truncatulina lobatula,** Walker and Jacob, sp.

Truncatulina lobatula, (W. & J.) d'Orbigny ('46), p. 168, pl. 9, figs. 18-23,

T. lobatula, (W. & J.) Williamson ('58), p. 59, pl. 5, figs. 121-123.

Planorbulina lobatula, (W. & J.), Goës ('94) p. 88, pl. 15, fig. 774.

This common foraminifer in the Delos gatherings, is subject to a great deal of variation, both as to size and contour. Common.

***Truncatulina refulgens,** Montfort, sp.

Truncatulina refulgens (Montfort), Brady ('65), p. 105, pl. 12, fig. 9.

T. refulgens (Montfort), Brady, ('84), p. 659, pl. 92, figs, 7-9.

The specimens are small, and good bell-shaped tests are very rare. Rare.

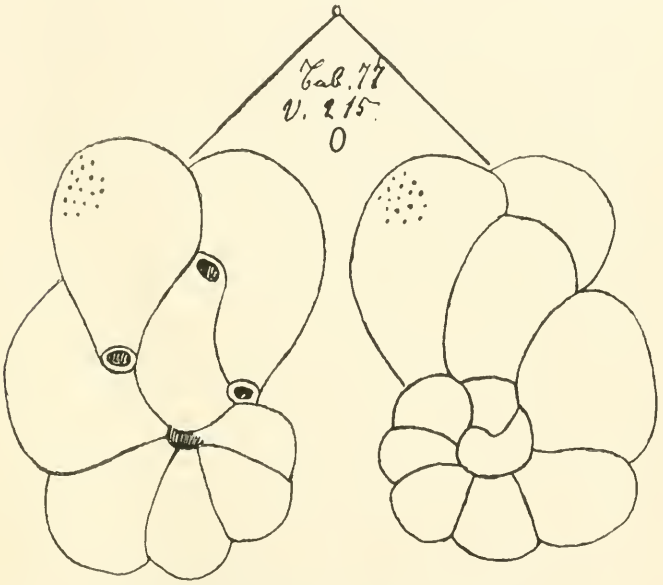
***Truncatulina variabilis,** d'Orbigny. (Pl. 1, Figs. 5, 6, and Pl. 2, Figs. 1-3).

Truncatulina variabilis (d'Orb.), Brady, ('84), p. 661, pl. 93, figs. 6, 7.

T. variabilis (d'Orb.), Brady, Parker and Jones, ('88), p. 227, pl. 45, fig. 17.

T. variabilis (d'Orb.), Jones and others, ('96), p. 309, pl. 6, fig. 23.

This occurs in two forms, one,* a small and rather feeble outspread and complanate variety, and the other * which is present in great numbers, very large, coarsely perforated, and often showing a number of heavily lipped



Truncatulina variabilis, d'Orb. After Soldani.

orifices. Except in the young stage, this latter variety shows hardly two specimens alike. The contour of the tests is often extraordinary, and the specimens are in some cases, found enveloping the stalks of weeds. In large examples, the perforations are very plainly seen, even under low powers, and the coalescing of their edges often forms an areolation over the whole surface. I had been puzzled over the identification of these forms, but

Professor A. Silvestri, of Spoleto, Italy, kindly sent me tracings of some of Soldani's figures in the "Testaceographia" of wild-growing *Truncatulina*, which d'Orbigny grouped under *Truncatulina variabilis*. Some of these tracings are almost identical with the Delos examples. I reproduce one of them in the text-figure on p. 3.

Many of the tests found are larger than those I have figured on Pl. 2.

*Truncatulina reticulata, Czjzek, sp. (Pl. 2, Fig. 4).

Rotalina reticulata, Czjzek ('48), p. 145, pl. 13, figs. 7-9.

Siphonina fimbriata, Terrigi ('80), p. 212, pl. 4, fig. 69.

Truncatulina reticulata (Czjzek) Brady ('84), p. 669, pl. 96, figs. 5-8.

T. reticulata (Czjzek) Brady, Parker and Jones ('88), p. 228, pl. 45, figs. 23, 24.

T. reticulata (Czjzek) Chaster ('92), p. 66, pl. 1, fig. 16.

The examples are characteristic of the species. Rare.

Carpenteria, Gray.

*Carpenteria, sp.? (Pl. 2, Fig. 5).

Having found only one specimen from Delos, and one from Palermo, I have not been able to decide definitely as to the genus of this foraminifer. The planorbuline arrangement of the chambers shows distinctly on the superior side (adherent surface) of the test. The edge of the test slightly spreads out, and is fimbriated; the aperture is an arched slit, and shows plainly, as will be seen from the figure. The perforations on both sides of the test show plainly. I have placed it under the head of *Carpenteria* provisionally.

Pulvinulina, Parker and Jones.

Pulvinulina repanda, Fichtel and Moll, sp.

Nautilus repandus, Fichtel and Moll ('03), p. 35, pl. 3, figs. *a—d.*

Pulvinulina repanda (F. & M.), Terrigi ('80), p. 206, pl. 3, fig. 61.

P. repanda (F. & M.) Brady ('84), p. 684, pl. 104, fig. 18.

P. repanda (F. & M.) Egger ('93), p. 405, pl. 18, figs. 28-30, 34, 35.

Very good examples occur. Frequent.

***Pulvinulina lateralis,** Terquem sp. (Pl. 2, Fig. 6, Pl. 3, Figs. 1, 2 (?)).

Rosalina lateralis, Terquem ('78), p. 25, pl. 2, fig. 11.

Pulvinulina lateralis (Terquem) Brady ('84), p. 689, pl. 106, figs. 2, 3.

P. lateralis (Terquem) Egger ('93), p. 413, pl. 18, figs. 48-50.

Mr. Millett in his Malay Report ('98—:04) states that this species in the living condition appears to be nothing more than a wild-growing variety of *P. repanda*, and that our knowledge of its distribution in the existing seas, is confined to the localities mentioned by Brady ('84) and the solitary station recorded by Egger. Mr. Millett states also that it "is tolerably plentiful at St. 22 of the Malay Report and is represented at a few stations mostly in Area 2." I can report it also from the Bay of Eleusis (not quite typical), Gulf of Oman, Madeira, Tuticoran, and White Dog's anchorage, off River Min, China. All the Delos examples (with one exception) are, I believe, wild growing specimens of this species. Those from Palermo do not suffer quite so much in this respect. Rare.

I am doubtful about the odd specimen Fig. 2, Pl. 3, as it bears a certain resemblance to Fornasini's (1900) outline figure on page 396, fig. 45, under the name *Pulvinulina adriatica*, of which it might possibly be an immature example. This specimen is much more complanate than the others.

* **Pulvinulina oblonga,** Williamson, sp.

Nautilus auricular, var. β, Fichtel and Moll (:03), p. 108, pl. 20, figs. *d*, *e*, *f*.

Rotalina oblonga, Williamson ('58), p. 51, pl. 4, figs. 98-100.

Pulvinulina oblonga, (Williamson), Brady ('84), p. 688, pl. 106, fig. 4.

Only about six of moderate size were found. Some of the Palermo tests are large. Very rare.

* **Pulvinulina oblonga,** (Williamson), var. **scabra**, Brady? (Pl. 3, Figs. 3, 4).

Pulvinulina oblonga (Williamson), var. *scabra*, Brady ('84), p. 689, pl. 106, fig. 8.

I am a little doubtful as to whether these should be placed under this species, or under *P. oblonga*. The tests run smaller than the Delos or Palermo examples of *P. oblonga*, but they can be distinguished by the fact that the surfaces of the earlier chambers on the superior side are concave, or flat, whereas in *P. oblonga* they are more or less convex.

In the Delos and Palermo specimens the rugosity of the superior surface is very seldom present. The final chambers of the tests are not so much inflated on the superior side, as are the specimens I have from Cebu, and especially those from Bermuda, nor is the amount of

rugosity so great. Brady's fig. 8*a*, pl. 106 ('84) does not convey the impression of having been drawn from the same example as fig. 8*c*, and it will be noticed that this latter figure gives the idea of the earlier chambers being convex, whereas all the tests in my collection show them to be flat or concave. Both the smooth and rugose condition are here figured. Rare.

* **Pulvinulina concentrica**, Parker and Jones, (Pl. 3, Fig. 5).

Pulvinulina concentrica (P. & J. Ms.), Brady ('64), p. 470, pl. 48, fig. 14.

P. concentrica (P. & J.), Brady ('84), p. 686, pl. 105. fig. 1.

Large examples occur of this beautiful foraminifer, the characteristic broad band bordering the chambers being well marked. Frequent.

***Pulvinulina hauerii**, d'Orbigny sp. (Pl. 3, Fig. 6).

Rotalina hauerii, d'Orbigny ('46), p. 151, pl. 7, figs. 22-24.

Pulvinulina hauerii (d'Orb.), Brady ('84), p. 690, pl. 106, figs. 6, 7.

The tests are not typical, their peripheral edges inclining to angularity. The clear portion of the surface of the final chamber on the inferior side is well marked and characteristic of the species. Rather rare.

***Pulvinulina karsteni**, Reuss, sp. (Pl. 3, Fig. 7).

Pulvinulina karsteni (Reuss), Brady ('64), p. 470, pl. 48, fig. 15.

P. repanda v. karsteni, Parker and Jones ('65), p. 396 pl. 14, figs. 14, 15, 17, and pl. 16, figs. 38-40.

P. karsteni (Reuss), Brady ('84), p. 698, pl. 105, figs. 8, 9.

The Delos examples of this species are not quite typical, the umbilical region being covered with granulations. Similar tests occur in the Bay of Naples. Rather rare.

Pulvinulina schreibersii, d'Orbigny, sp. (Pl. 3, Fig. 8).

Rotalina schreibersii, d'Orbigny ('46), p. 154, pl. 8, figs. 4-6.

R. badensis, Czjzek ('48), p. 144, pl. 13, figs. 1-3.

Pulvinulina schreibersii (d'Orb.), Brady ('84), p. 697 pl. 115, fig. 1.

The Delos specimens reveal this to be one of the most beautiful of the foraminifera, of which it is impossible to give adequate illustrations.

The test is very transparent, and looking down upon its apex the minute tubuli appear like very small delicate feathers. There is generally a "boss" in the centre of the lower surface, and the amount of stellate sutural limbation varies considerably, as also does the height of the spire. The examples are in splendid condition, and of a very pale, light-brown colour. Brady ('84), states that Parker and Jones record its occurrence in the Red Sea, 40 fathoms, and in the Mediterranean, 90 fathoms Very frequent.

***Pulvinulina vermiculata**, d'Orbigny, sp. (Pl. 4, Fig. 1).

Pulvinulina vermiculata (d'Orb.), Carpenter ('62), p. 211, pl. 13, figs. 4-6.

P. vermiculata (d'Orb.), Brady ('84), p. 687, pl. 115, fig. 2.

This is an interesting form, and large and characteristic specimens occur in these Delos gatherings. Rather rare.

Pulvinulina nitidula, Chaster. (Pl. 4, Fig. 2).

Pulvinulina nitidula, Chaster ('92), p. 66, pl. 1, fig. 17.

Dr. Chaster's description of this pretty little species, which occurs off Southport, Lancashire, runs as follows:

"Test small, much depressed, highly polished; convolutions about two in number, there being seven or eight segments in the last; superior surface slightly convex; sutures not depressed; inferior surface concave; aperture large and oblique; periphery acute. Diameter, ·125 mm. The test is so thin that the sutures on the inferior surface are seen through the shell, and give it a pseudo-Cassiduline appearance. Shore mud and in shallow water. Very rare."

The tests from Delos are quite typical. I have also three specimens from the coast of Iceland. Rather rare.

Pulvinulina globosa, n. sp. (Pl. 4, Fig. 3).

Test clear and delicate, composed of three convolutions, made up of about thirteen inflated chambers, consequently the sutures are deeply sunk. The aperture appears to be concealed in the deeply sunk umbilical region by granular shell growth. The final convolution consists of five chambers, and these are adorned on the inner surface by very fine lines, radiating from the umbilicus. The test is very smooth, and finely perforated, and of an irregular globular shape.

About ten specimens were found of this minute species. The one figured is the largest of the set. Very rare.

Pulvinulina simplex, n. sp. (Pl. 4, Figs. 4, 5).

The test is transparent, and consists of four, five, or six segments, having generally only four peripheral segments. The initial chamber is comparatively large.

The test is compressed, elongated, and has the periphery rounded. The umbilical cavity is deeply sunk, and has a few very fine lines ornamenting its sides. The sutural lines are slightly sunk. This simple *Pulvinulina* appears to belong to the "*oblonga*" group. Rare.

Rotalia, Lamarck.

*Rotalia beccarii, Linné, sp. (Pl. 4, Fig. 6).

Rotalina beccarii (Linné), Williamson ('58), p. 48, pl. 4, figs. 90-92.

Rotalia beccarii (Linné), Parker and Jones ('65), p. 388, pl. 16, figs. 29, 30.

R. beccarii (Linné), Brady ('84), p. 704, pl. 107, figs. 2, 3.

R. beccarii (Linné) Goës ('94), p. 99, pl. 16, fig. 811.

R. beccarii (Linné), Flint ('99), p. 331, pl. 75, fig. 2.

Three varieties of this common species are present, one* small, with the outermost whorl consisting of six to eight chambers, and a second* variety, much larger, with ten or eleven chambers in the final convolution. The former rather rare, the latter common. In this latter the septal lines are often limbate and raised. The third* variety, which is very rare (*Fig. 6, Pl. 4*), is the largest of the set, and highly decorated with tubercles, and exogenous shell-growth. Mr. Millett kindly sent me a couple of examples of this decorated form from the Pliocene of St. Erth, and they agree well with those from Delos. He writes me that he had listed them as *Rotalia punctato-granosa*, Seguenza, but now considers them to be a variety of *R. beccarii*, and also states that as far as he knows this is its first recorded occurrence in the recent condition. It is not quite so rare off Palermo.

TINOPORINÆ.

Gypsina, Carter,

***Gypsina globulus,** Reuss, sp.

Ceriopora globulus, Reuss ('47), p. 33, pl. 5, fig. 7.

Gypsina globulus, (Reuss) Brady ('84) p. 717, pl. 101, fig. 8.

G. globulus (Reuss) Brady, Parker and Jones ('88), p. 229, pl. 46, fig. 13.

The specimens are not quite so symmetrical as the one figured by Brady ('84), and it is possible that some of them might be brought under *G. vesicularis*. Rare.

Gypsina inhœrens, Schultze, sp.

Acervulina inhœrens, Schultze ('54), p. 68, pl. 6, fig. 12.

Gypsina inhærens (Schultze) Brady ('84), p. 718, pl. 102, figs 1-6.

One of the examples is very similar to Brady's fig. 3 in the above reference, being wrapped round the stem of some object. Several also agree with Brady's figs, 1, 2. Very rare.

Polytrema, Risso.

* **Polytrema miniaceum**, Linné, sp. (Pl. 4, Fig. 7.)

Polytrema miniaceum (Linné) Brady ('84), p. 721, pl. 100, figs. 5-9, and pl. 101, fig. 1.

P. miniaceum (Linné) Schlumberger ('92), p. 196, fig. 5.

This common Mediterranean form is present in great numbers, many of the specimens being finely branched. In the above reference Schlumberger states that he found this species in the embryonic stage in material from the Azores. This stage is represented by a small irregular globular test, rosy in colour, and free. I have found

about twenty-five* in the Delos gatherings. Schlumberger also refers to the fact that a section made through the trunk of an adult specimen, not far from the attached surface, reveals the embryo embedded in it.

My own sections shewed them very plainly. Very common.

***Polytrema miniaceum** (Linné), var. **alba**, Carter.

Polytrema miniaceum, var. Carter ('77), p. 213, pl. 13, fig. 14.

P. miniaceum (Linné), var. *alba* (Carter), Brady ('84), p. 721, pl. 101, figs. 2, 3.

This variation occurs both in the adult and embryonic stages, but is very rare. The colour is not snow-white, but rather a *very* light shade of cream-colour.

They agree with specimens I have from Cebu.

NUMMULINIDÆ.

POLYSTOMELLINÆ.

Nonionina, d'Orbigny.

Nonionina depressula, Walker and Jacob, sp.
(Pl. 4, Fig. 8).

Nonionina umbilicatula, Williamson ('58), p. 97, pl. 3, figs. 70, 71.

Polystomella crispa, var. (*Nonionina*) *depressula*, Parker and Jones ('65), p. 403, pl. 14, fig. 39.

N. depressula (W. & J.), Terrigi ('80), p. 218, pl. 4, fig. 77.

N. depressula (W. & J.), Brady ('84), p. 725, pl. 109, figs. 6, 7.

N. depressula (W. & J.), Goës ('94), p. 103, pl. 17, figs. 825, 826.

The tests agree well with the "Challenger" figures, although they do not all show the granular markings at the umbilicus. Rather rare.

***Nonionina stelligera,** d'Orbigny, (Pl. 4, Fig. 9).

Nonionina stelligera, d'Orbigny ('39), p. 128, pl. 3, figs. 1, 2 (*stellifera* on plate).

Polystomella crispa, var. (*Nonionina*) *stelligera*, d'Orb., sp., Parker and Jones ('65), p. 404, pl. 14, figs. 40, 41.

Nonionina stelligera (d'Orb.), Brady ('84), p. 728, pl. 109, figs. 3-5.

N. stelligera (d'Orb.), Morton ('97), p. 121, pl. 1, fig. 18.

The Delos tests of this species are much more stoutly built than those of the former, which are delicate and colourless, while the latter are semi-opaque and of a pale ivory colour. Rather frequent.

***Nonionina scapha,** Fichtel and Moll, sp.

Nautilus scapha, Fichtel and Moll (:03), p. 105, pl. 19, figs. *d-f*.

Nonionina sloanii, d'Orbigny ('39), p. 46, pl. 6, fig. 18.

N. scapha (F. & M.), Brady ('84), p. 730, pl. 109, figs. 14, 15.

N. scapha (F. & M.), Brady, Parker, and Jones ('88), p. 230, pl. 43, fig. 20.

N. scapha (F. & M.), Flint ('99), p 337, pl. 80, fig. 1.

The Delos examples are small and transparent. Very rare.

***Nonionina turgida,** Williamson, sp.

Rotalina turgida, Williamson ('58), p. 50, pl. 4, figs. 95-97.

Polystomella crispa, var. (*nonionina*) *turgida*, Parker and Jones ('65), p. 405, pl. 17, fig. 57.

Nonionina turgida (Williamson), Brady ('84), p. 731, pl. 109, figs. 17-19.

All the specimens are developed inequilaterally. Rare.

Polystomella, Lamarck.

***Polystomella striatopunctata,** Fichtel and Moll, sp.
(Pl. 4, Fig. 10, and Pl. 5, Figs. 1, 2.)

Nautilus striatopunctatus, Fichtel and Moll (:03) p. 61, pl. 9, figs. *a-c*.

P. striatopunctata (F. & M.). Terrigi ('80), p. 216, pl. 4., figs. 73, 74.

P. striatopunctata (F. & M.), Brady ('84), p. 733, pl. 109, figs. 22, 23.

Polystomella striatopunctata (F. & M.), Brady, Parker, and Jones ('88), p. 230, pl. 43, fig. 17.

This common and variable species occurs in three forms. The first, as figured Pl. 4, Fig. 10, is transparent and much flattened, and the "fossettes" are feebly marked. In the second* variety, Pl. 5, Fig. 1, the test is much stouter, the perforations shew distinctly, and the "fossettes" in certain lights shew a fine, or a dotted line, on either side, proceeding from the umbilicus to the periphery. These lines are somewhat too distinct in the illustration. The third form, Pl. 5, Fig. 2, has the whole of the test (in most cases) apparently very finely granulated, especially in the region of the "fossettes," this giving the test a banded appearance. When damped the "fossettes" shew quite plainly.

The first variety, rather rare; the second, frequent; and the last, not so frequent.

***Polystomella crispa** (Linné), sp.

Polystomella crispa (Linné), Williamson ('58), p. 40, pl. 3, figs. 78-80.

P. crispa (Linné), Carpenter ('62), p. 278, pl. 16, figs. 4-6.

P. crispa (Linné), Brady ('84), p. 736, pl. 110, figs. 6, 7.

P. crispa (Linné), Flint ('99), p. 338, pl. 80, fig. 3.

Fine and typical examples are common from this locality.

***Polystomella verriculata**, Brady. (Pl. 5, Fig. 3).

Polystomella verriculata, Brady ('84), p. 738, pl. 110, fig. 12.

P. verriculata (Brady), Millett (:04), p. 604, pl, 11, fig. 3.

The Delos examples are small, and not very well developed. The net-work appearance caused by the joining of the septal ridges and retral bars, as a rule, only shows on the earlier chambers. Very rare.

***Polystomella macella**, Fichtel and Moll, sp. (Pl. 5, Fig. 4).

Nautilus macellus, var. *a*, Fichtel and Moll, (:03), p. 66, pl. 10, figs. *e-g*.

Polystomella lessonii, d'Orbigny ('39), p. 29, pl. 3, figs. 1-2.

P. fichteliana, d'Orbigny ('46), p. 125, pl. 6, figs. 7, 8.

P. macella (F. and M.), Brady ('84), p. 737, pl. 110, figs. 8, 9, 11.

Good examples of this species are present. The tests are typical, with a slightly depressed umbilicus, and acute peripheral edge. Some of the tests are flatter than the one illustrated, and have spines projecting from the edge of the earlier chambers. I have still finer specimens from dredgings near Mount Athos. Rather rare.

***Polystomella macella**, Fichtel & Moll., var. **granulosa**, nov. (Pl. 5, Fig. 5).

This is an interesting variation, in which the limbate sutures are broken up into exogenous beads, and the whole of the test is likewise covered with minute granules or tubercles. The "fossettes" show quite plainly when the test is damped. Two or three poor examples occur at Palermo. Rather rare.

***Polystomella subnodosa**, Münster, sp. (Pl. 5, Fig 6).

Polystomella subnodosa, (Münster) Reuss, ('55), p. 240, pl. 4, fig. 51.

P. subnodosa (Münster) Brady ('84) p. 734, pl. 110, fig. 1.

P. subnodosa (Münster) Goës ('94) p. 102, pl. 17, figs. 817-819.

The tests are of a very pale milky-blue colour, slightly transparent. The surface is polished, and the pores hardly apparent under moderate powers. I have a note from Mr. Millett, dated a few years ago, in which he says "Goës figures specimens under this name from Newfoundland and Nova Zemlya. His figures are doubtful. As a recent shell it had only been found in the Eastern Archipelago until you obtained it from Delos."

Since this note, Mr. Millett reports its occurrence in the Malay Archipelago, saying it is found in both areas, and is abundant at stations 13, 18, and 21. I have also examples from the Bays of Salona and Eleusis. Very frequent.

APPENDIX.

***Miliolina ferussacii,** d'Orbigny, sp. (Pl. 5, Fig. 7.)

Quinqueloculina rodolphina, d'Orbigny ('46), p. 299, pl. 20, figs. 7-9.

Q. Mariæ, d'Orbigny ('46), p. 300, pl. 20, figs. 13-15.

Miliolina ferussacii (d'Orb.), Brady ('84), p. 175, pl. 113, fig. 17.

The specimens found are apparently very feeble examples of the elongated variety of *M. ferussacii*. Those from Palermo are also elongated, but better developed, and finer in every way. Rare.

Miliolina contorta, d'Orbigny, sp. (Pl. 5, Fig. 8.)

Quinqueloculina contorta, d'Orbigny ('46), p. 298, pl. 20, figs. 4-6.

This appears to be a weak form of this variable foraminifer, in which the chambers have lost most of their angularity. The specimens vary a good deal in this respect, and in the one selected for illustration the angularity is hardly apparent. Frequent.

Miliolina, sp. (Pl. 5, Fig. 9.)

There are four or five of these, of which the one figured is the largest, and has the costæ much more developed than the others have. All the tests appear to be distorted, and I feel doubtful under which species they should be placed. The test is very much compressed, and keeled, and the mouth is a narrow slit. Terquem figures specimens from the Pliocene of the Isle of Rhodes ('78), p. 70, pl. 13 (pl. 8), figs. 4, 8, under the name of *Quinqueloculina depressa* d'Orbigny, which bear a certain amount of likeness to the Delos forms, especially his

fig. 8, which appears to resemble one of the smallest of the Delos examples. Very rare.

***Discorbina parisiensis**, d'Orbigny, sp. (Pl. 5, Fig. 10).

Discorbina parisiensis (d'Orb.), Wright ('77), p. 105, pl 4, fig. 1.

D. parisiensis (d'Orb.), Brady ('84), p. 648, pl. 90, figs. 5, 6, 9-12.

Five were found, of which the one figured has the highest spire, and shows only four chambers in the outermost convolution. One of the tests is quite flat, and excepting the figured specimen, they all have five chambers in the final convolution. Very rare.

***Discorbina**, sp. (Pl. 5, Fig. 11).

I am unable to determine to what species this belongs, and Mr. Millett "thinks it may be an immature form of *Discorbina vilardeboana*, or *D. vesicularis*, or even *D. globularis*, and should be judged by its associates," but in this respect there appears to be nothing to guide me. The tests are very transparent, and the umbilical cavity deeply sunk. Very rare. Not so rare at Palermo.

NOTE.

I hope next year to deal with the foraminifera from Palermo, describing and illustrating the species that occur there and not at Delos. This contribution, taken in conjunction with my Delos papers, will give a complete record for Palermo.

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ERRATA.

Line 18, vol. 48, 1904, p. 18, for d'Orbigny sp. read Schlumberger.

,, 2, from foot, p. 24, for Chelaston, near Derby, read Lias of Leicestershire.

,, 5, from foot, p. 26, for d'Orbigny sp. read Schlumberger.

,, 13, from foot, vol. 51, 1907, p. 7, for **fragraria** read **fragaria**.

,, 10, from foot, p. 7, for *fragraria* read *fragaria*.

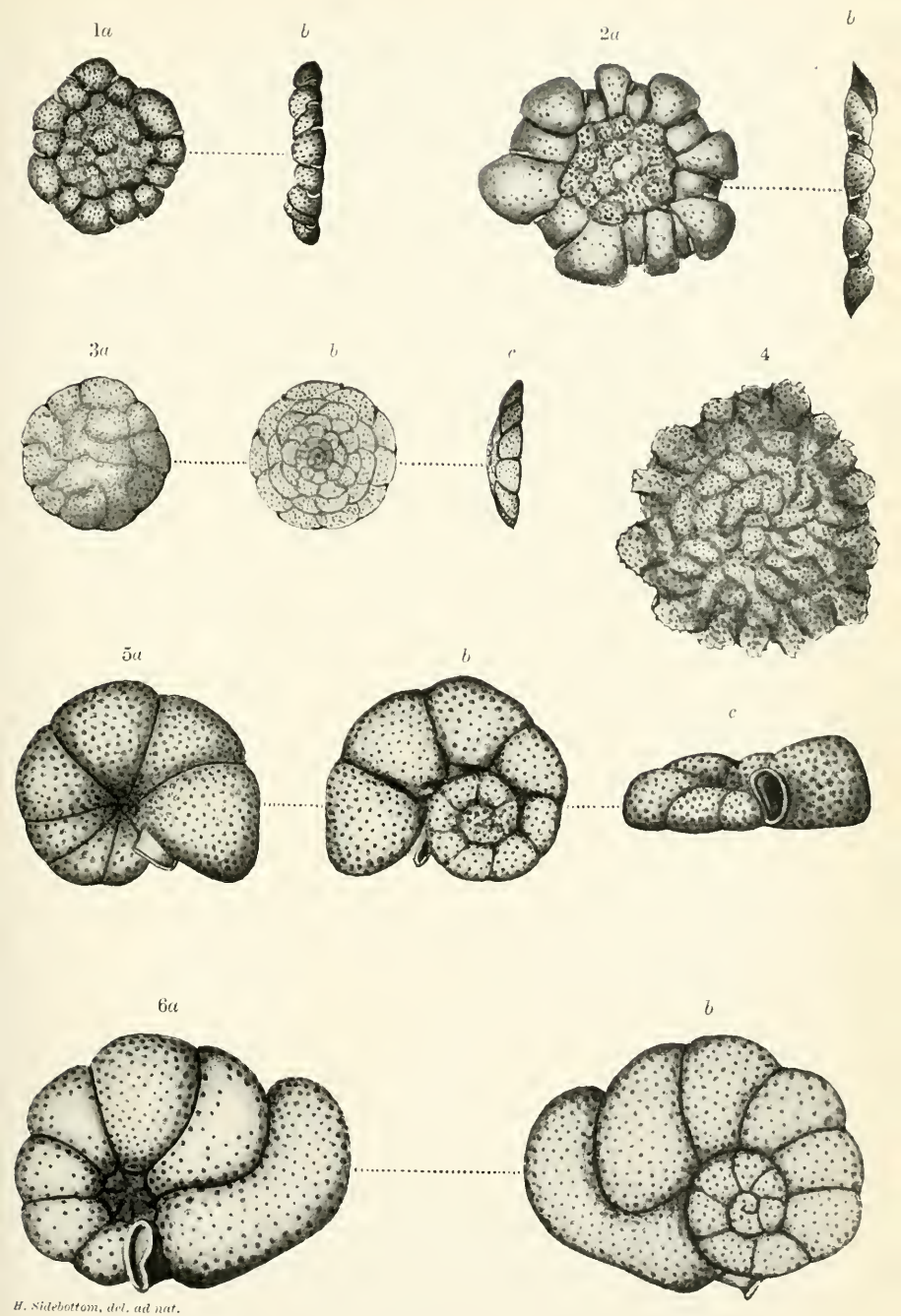
,, 5, from top, p. 24, for *fragreria* read *fragaria*.

Plate 3, erase lines between figs. 12 and 13.

EXPLANATION OF PLATES.

PLATE I.

FIGS.			PAGE.
1—3.	*Planorbulina mediterranensis*, d'Orbigny	× 25	1
4.	*Planorbulina acervalis*, Brady	× 25	2
5, 6.	*Truncatulina variabilis*, d'Orbigny	× 50	2

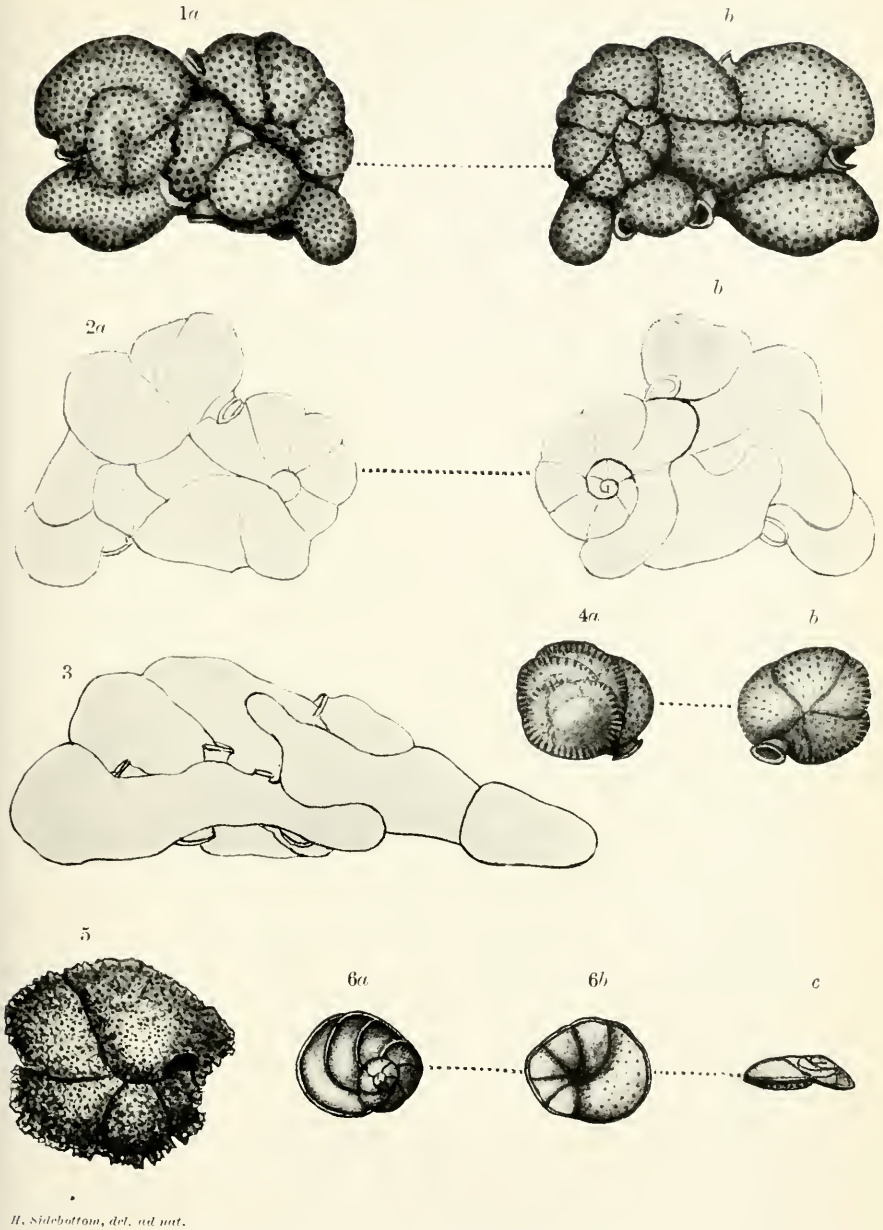


H. Sidebottom, del. ad nat.

Foraminifera from the coast of the island of Delos.

PLATE II.

FIGS.			PAGE.
1—3.	*Truncatulina variabilis*, d'Orbigny	× 25	2
4.	,, *reticulata*, Czjzek, sp.	× 50	4
5.	*Carpenteria*, sp?	× 25	4
6.	*Pulvinulina lateralis*, Terquem, sp.	× 25	5

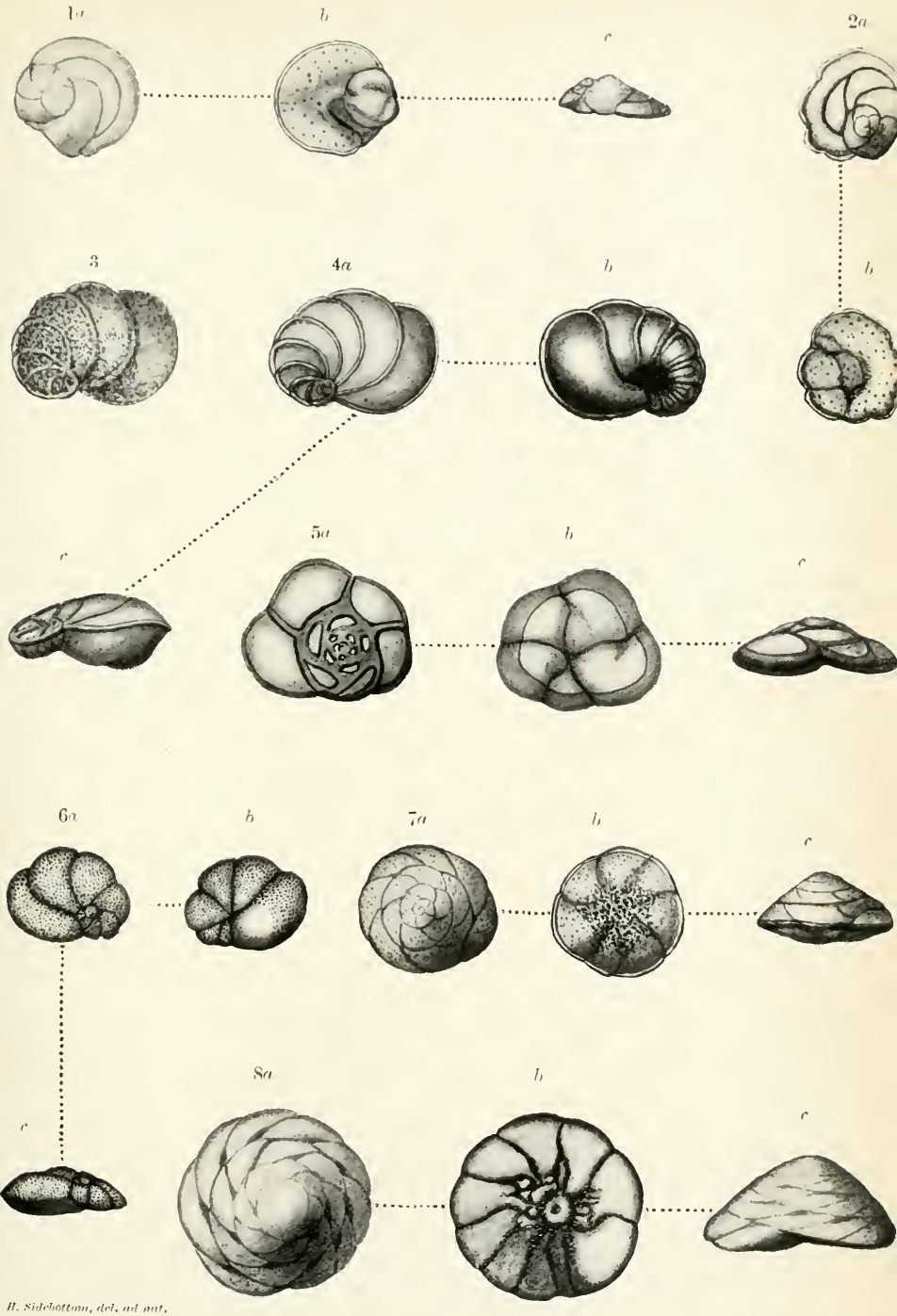


H. Sidebottom, del. ad nat.

Foraminifera from the coast of the island of Delos.

PLATE III.

FIGS.			PAGE.
1, 2 (?)	*Pulvinulina lateralis*, Terquem, sp.	× 25	5
3, 4.	,, *oblonga* (Williamson), var. *scabra*, Brady ?	× 50	6
5.	,, *concentrica*, Parker and Jones	× 25	7
6.	,, *hauerii*, d'Orbigny, sp.	× 50	7
7.	,, *karsteni*, Reuss, sp.	× 50	7
8.	,, *schreibersii*, d'Orbigny	× 25	8

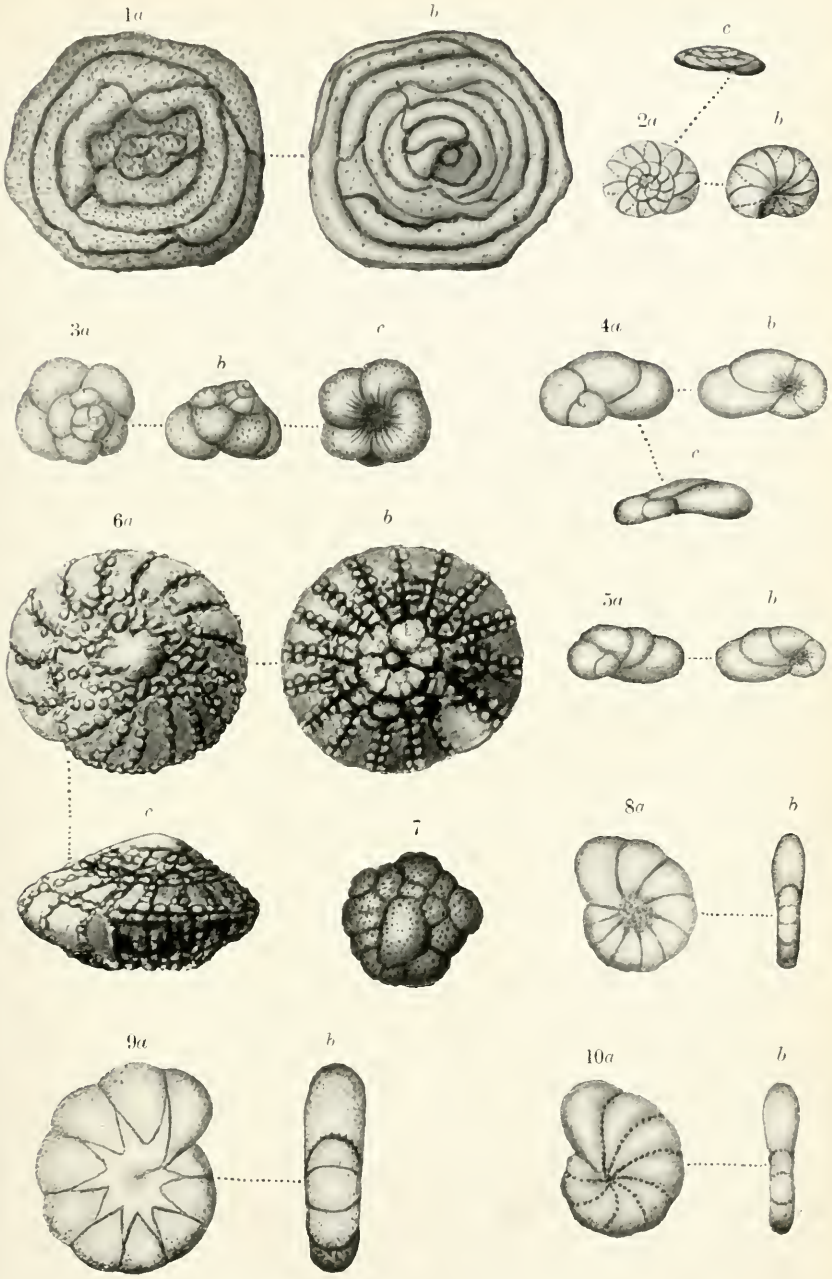


H. Sidebottom, del. ad nat.

Foraminifera from the coast of the island of Delos.

PLATE IV.

FIGS.			PAGE.
1.	*Pulvinulina vermiculata*, d'Orbigny	× 25 ..	8
2.	,, *nitidula*, Chaster	× 75 ...	9
3.	,, *globosa*, n. sp.	× 75 ..	9
4, 5.	,, *simplex*, n. sp.	× 75 ...	9
6.	*Rotalia beccarii*, Linné, sp. var.	× about 18 ...	10
7.	*Polytrema miniaceum* (embryonic stage)	× 50 ...	11
8.	*Nonionina depressula*, Walker and Jacob, sp.	× 75 ...	12
9.	,, *stelligera*, d'Orbigny	× 50 ...	13
10.	*Polystomella striatopunctata*, Fichtel and Moll, sp.	× 75	14

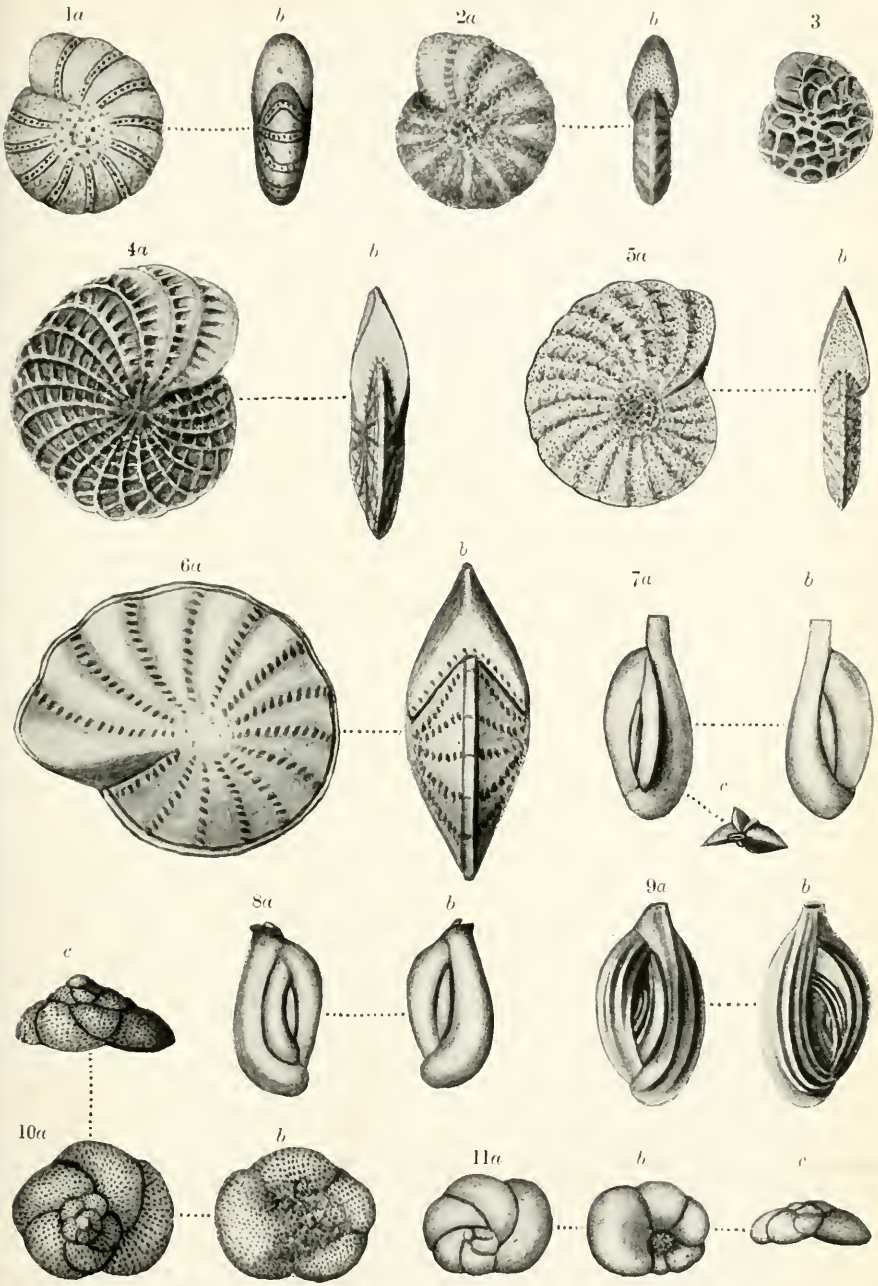


H. Sidebottom, del. ad nat.

Foraminifera from the coast of the island of Delos.

PLATE V.

FIGS.		PAGE.
1, 2.	*Polystomella striatopunctata*, Fichtel and Moll, sp. × fig. 1, 50, fig. 2, 75	14
3.	,, *verriculata*, Brady × 75	15
4.	,, *macella*, Fichtel and Moll, sp. × 50	15
5.	,, *macella* (F. & M.), var. *granulosa*, nov. × 50	16
6.	,, *subnodosa*, Münster, sp. × 50	16
7.	*Miliolina ferussacii*, d'Orbigny, sp. × 50	17
8.	,, *costata*, d'Orbigny, sp. × 50	17
9.	,, sp. × 50	17
10.	*Discorbina parisiensis*, d'Orbigny, sp. × 75	18
11.	,, sp. × 75	18



H. Sidebottom, del. ad nat.

Foraminifera from the coast of the island of Delos.

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XXII. British Permian Footprints.

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Introduction.

The main object of this communication is to give a review of the known fossil footprints from the Permian rocks of this country, and to show that they may be used for the purpose of distinguishing Permian from Triassic deposits. In this manner two important series of rocks may, I believe, already be shown to belong to the former series, viz., the Red Sandstones of Dumfriesshire, and the footprint-bearing beds near Elgin ; while the impressions recently discovered near Exeter will doubtless throw light on the age of the Devonshire red rocks. (Clayden, :08*a*, :08*b*).

In 1906 I published a description and figures of a series of footprints from a sandstone intercalated in the Magnesian Limestone of Mansfield, Notts. (Hickling, :06). No impressions had previously been figured from the undoubted Permians of this country, one collection only having been briefly described by Mr. Varty Smith from Penrith (Smith, Varty, '84). Through the kindness of Mr. Smith I have recently been able to examine those prints, the more definite of which are figured in *Plate II., Figs.* 9—13. On examining the quarry in which the Mansfield impressions were found, I discovered numerous other impressions, the description of which has been

postponed in the hope that the quarry, which has been standing for some years, would be re-opened. It now appears to me desirable to call attention to what is already known without further delay.

I shall first refer briefly to the new prints from Mansfield, and then to the Penrith specimens. Those two collections, being definite Permian, will serve as a basis for comparison. The Dumfries prints will then be considered: outlines of them are given in *Plate III.*, as the existing figures are very inaccessible. The prints from Elgin and Exeter will follow, and lastly a comparison will be drawn between the British and Thüringian Permian prints, and between the Permian and Carboniferous forms.

Detailed descriptions of the impressions will not be given. Figures alone can characterise footprints sufficiently.

It does not appear to be desirable that footprints should bear biological names; yet some index by which they may be referred to is essential, and an indication of the groups in which they may be arranged is valuable. Names for such groups are also useful. The dominant type of impression in the British Permians appears undoubtedly to be that to which the prints, named by Jardine "Chelichnus" (Jard., '50), belong. Impressions of this "chelichnoid" group may therefore be indicated by the letters Cl., with a number to indicate the particular form. Other groups may be treated in a similar manner. This is essentially the same system as that used by Mr. Beasley in treating the Triassic footprints (Beasley, :03).

THE MANSFIELD FOOTPRINTS.

Chelichnoid forms.—The large prints already described (Hickling, :06) appear to belong to this group as possessing

the following characters: The prints are oval in form, with the digits directed forwards, increasing in length from I. to IV., III. and IV. being nearly equal, and V. much shorter. There is a broad "sole," rounded behind, and the sand is pressed out in a mound behind the impressions. In the track, the impressions of the right and left sides are widely separated.

These impressions are shown in *Plate I.*, *Figs.* 1*p* (pes), 1*m* (manus) and 1*b* (portion of the track). The first digit is not shown in the manus, but was probably present. The toes were almost certainly webbed, and it is therefore difficult to determine their true outline. These and all other figures in *Plates I.*, *II.* and *III.*, (except those of tracks) are exactly half natural size.

I propose to refer to these impressions as *Cl.* 7. They are represented by a small slab in the Manchester Museum, Owens College (L 6334) and a large slab, from a portion of which the track, *Fig.* 1*b* is drawn, at the Nottingham Museum.

There are numerous other chelichnoid forms to be found in the Mansfield quarries, mostly of smaller dimensions, but I have not found examples sufficiently good to figure.

Unclassified forms.—The remaining Mansfield types do not belong to groups which I feel justified in naming. It would seem convenient to indicate all unclassified prints by the letter *x*.

Fig. 2, *Plate I.*, shows a large print which needs no further description. It was a very light impression. I was not able to collect the slab, and drew the print on the spot. It appears to be identical with a form from Dumfries (*Plate III.*, *Fig.* 16). It may be referred to as *x*4.

Fig. 3, *Plate I.*, is a small print showing four digits (I. to IV.,) with a doubtful indication of V. It was an

isolated print on a large slab, and was drawn in the quarry. There is little to separate it from impressions from Penrith (*Plate II., Fig.* 9) and Elgin (*Plate II., Figs.* 7 and 8). It may be termed *x*3.

In *Fig.* 4 is represented a footprint from Mansfield now in the Manchester Museum (L. 6894). Digits II., III., IV., and V. are well shown, III. being the longest, and a slight impression of I. indicating it as a much shorter digit. This print appears to be identical with those forming an unnamed track from Dumfries in the Edinburgh Museum (*Plate III., Fig.* 19). In the Dumfries prints digit V. is not shown. There may be a doubt as to whether it really occurs in the Mansfield specimen, as it is confused with another small print. I propose to call this form *x*5.

The last Mansfield print figured (*Fig.* 5) is quite unlike any other I have seen. I was not able to collect it. Being a strongly characterised form it will be useful for comparison with future discoveries elsewhere.

PENRITH FOOTPRINTS.

These prints occur in the well-known Penrith Red Sandstone. Further particulars of the occurrence will be found in the original account by Mr. Varty Smith (Smith, G. V., '84). Most of the individual prints are imperfect, but good tracks are abundant in the quarries.

Chelichnoid forms.—Numerous small representatives of this type occur. *Plate II., Fig.* 13, shows a typical track, with the prints of the manus partly obliterated by those of the pes, and the typical semilunar mound behind the prints. Other tracks of this type show a considerable amount of variation in the relative position of manus and pes, in size, and in length of stride. These points taken

together would appear to indicate the presence of several species.

Figs. 10, 11, and 12 show some individual prints of these forms which indicate the form more clearly. In all of them the impression of the "sole" appears to be incomplete (*cf. Chelichnus ambiguus*, *Plate III.*, *Fig.* 21). It is improbable that these three figures belong to really identical forms, but until better material is available I think it is better to group them together under the title *Cl.* 6.*

Lacertoid form.—Fig. 14 represents a very interesting isolated print on one of Mr. Varty Smith's slabs. It is unlike any other British Permian impression I have seen, but it agrees with certain impressions from the Thüringian Permian, and from the Kansas Coal Measures, in possessing 5 slender curved digits, with ball-like pads, the fifth being "thumb-like," and in having little or no trace of a "sole." This type of foot is very characteristic of modern lizards, and I think the term "lacertoid" may be aptly applied to it. This print will therefore be *Lc.* 1.

Other forms.—Fig. 9 has already been mentioned as nearly identical with *x*3 from Mansfield. In many of the impressions, the fifth digit (left in the figure) is absent, and the agreement is then very marked. Only the difference of locality, and a slight difference in size, lead me to provisionally separate it. The track is almost

* Note.—Since writing the above I have received a photograph of the slab on which I found the original of *Fig.* 12, and which I was not able to examine fully in the quarry. It is now possible to trace the track to which the print belongs, and to see that this form is not, as I had supposed, allied to those shown in *Figs.* 10 and 11, but is *a Herpetichnoid form*, having the toes turned inwards nearly at right angles to the track. It must therefore be designated *Hp.* 3.

This instance serves to illustrate the necessity for observing prints in tracks, and not merely individually.

identical with that shown in *Fig.* 13, except in the digits alone being shown. This fact raises a suspicion that these forms may really be chelichnoid, in spite of the apparent difference. These prints may be referred to as *x*2.

Several other types occur at Penrith, too imperfect for description.

THE DUMFRIESSHIRE FOOTPRINTS.

A considerable literature exists in reference to these impressions, but practically the only figures are those in Sir Wm. Jardine's "Ichnology of Annandale," a very inaccessible folio.

The footprints have been found in a number of quarries extending over a considerable tract. The following is a list: Corncockle Muir, Applegarth; Templand quarries, Lochmaben; Craigs Quarry, Dumfries; Green Mill Quarry, Caerlaverock; Locherbriggs (Harkness, '51).

The rocks in which the impressions occur, have been transferred from Trias to Permian, and back again many times. Until recently they were mapped by the Survey as Permian, but lately they have been returned to the Trias. I trust the evidence now considered, will be allowed to settle them definitely in the Permian.

Chelichnoid forms.—In 1828, the Rev. Dr. Duncan described the first fossil footprints from Corncockle Muir before the Royal Society of Edinburgh (Duncan, '28).

The one track figured by Duncan was again figured by Buckland from a cast and referred by him to a tortoise (Buckland, '36, p. 261), and was named *Testudo Duncani* by Owen (Owen, '41). Jardine gave the name *Chelichnus Duncani* (Jard., '50).

This track is here figured from a cast in the Manchester Museum, which I believe to be a copy of that figured by

Buckland (*Plate III., Figs.* 20, 20*b*). The cast only shows four digits distinctly in the best print of the pes (*Fig.* 20), but it seems evident that the first digit was really present. Both Duncan and Buckland describe it as really having five digits. The third and fourth digits are nearly equal in length ; the fifth is short and turns outwards. The impressions of the pes immediately precede those of the manus, sometimes nearly obliterating the latter (*Fig.* 20*b*). The pes and manus appear practically identical. There are large mounds of sand behind each impression. Specimens are in the Edinburgh Museum. This print will be termed *Cl.* 1.

Chelichnus ambiguus, Jard. (Jard., '53, plates *VI.* and *XI.*) is drawn in *Figs.* 21 and 21*b*, taken from Jardine's plate *VI.* This form differs from *Cl.* 1 in its more slender digits, and in showing distinct evidence of a web between them. The prints are smaller and the track less wide. All the prints in this track are less deeply impressed, but this is much more marked in the anterior than in the posterior impressions. I believe the anterior represent the manus, but this is not quite clear. The fifth digit is nowhere shown. There is an example in the Edinburgh Museum. This form will be described as *Cl.* 2.

Batrichnus Lyelli, Harkness sp., is shown in *Fig.* 22, from Jardine's plate *XIII.* It was described by Harkness (Hark., '51, p. 94) as a "Labyrinthodon" (*i.e.* a cheirotheiroid print), under the name *Labyrinthodon Lyelli.* The only reason, apparently, for this curious reference is the small manus. The track is of the usual chelichnoid type, as are the prints themselves. The prints figured by Jardine are not very clear, and *Fig.* 22 has been drawn by a careful comparison of several. I have no doubt as to its correctness. There are distinct marks of a web in

some of the impressions. Harkness describes the small manus as having five thick short digits. Jardine mentions three or four. I cannot distinguish more than four. The name *Batrichnus* was instituted by Harkness in the foregoing paper for another allied print.

It may be thought that the very small manus of this form, should cause its removal from the chelichnoid group. As, however, it agrees in all other essentials, with the members of that group, and as they show considerable variation in the proportions of pes and manus, I prefer to keep it here under the term *Cl.* 3. This form is recorded only from Green Mill, Caerlaverock. The type is in the Edinburgh Museum.

Herpetichnus Bucklandi, Jard. (Jard., '50, p. 209) is shown in *Fig.* 18, from Jardine's plate *VII.* It is a very unsatisfactory print, which I should not have figured but for the fact that similar small impressions are common at Mansfield. The track is broad and rather irregular, the prints being in pairs in the relative position indicated in the figure. There is nothing to indicate which is pes and which manus. Jardine states that four digits are sometimes discernible. I see no reason whatever for referring it to the herpetichnoid group. So far as it can be made out, it seems to be a small chelichnoid form. It may be referred to as *Cl.* 4.

Herpetichnoid forms.—The "genus" *Herpetichnus* was founded by Jardine in 1850 (Jard., '50).

Herpetichnus saurioplesius, Jard. (Jard., '50, p. 209), is stated by Jardine to be one of those originally described by Duncan (presumably the No. 3 of Duncan's account) and to be the commonest type of impression after *Cl.* 1. They are, unfortunately, nearly always imperfect. *Fig.* 17 shows a right pes and manus from

Jardine's plate *V.* The pes shows well the characteristic features of the group—the inwardly-directed digits, digit IV. being the longest and furthest advanced. The impression of the first digit is very slight. The associated manus figured is unusual in form—ordinarily, it is elongated like the pes. Jardine states that it shows four toes, and evidently regards the longest one as digit III. If this is really the case, it is difficult to reconcile this manus with the usual form. My own conviction is, that what looks like the outermost digit, is an impression due to some pad on the "sole," and that three digits only are really shown (III., IV., and V.), though I. and II. were probably also present, and directed inwards as in the foot. This interpretation is supported by the other manus on the same slab which certainly only shows three digits.

The track of this form was narrow, for a Permian one. Jardine states that it sometimes reached a considerably greater size. This type may be termed *Hp.* 1.

Herpetichnus loxodactylus, Dudgeon, is the only new print hitherto described from Dumfries since Jardine's account, as far as I have been able to discover (Dudgeon, '78). *Fig.* 23, taken from Dudgeon's plate, represents a cast of the right pes (*i.e.*, a left pes, if regarded as an impression). Only the impression of the "ball" of the fifth digit appears. Were the claw shown, the resemblance to *Hp.* 1 would be more marked. The manus was smaller, with a length of 2·3 inches against 3·5, and was placed 2 inches in front of the pes. The stride was 10 inches. The print was obtained from Locherbriggs quarry. It will constitute the type *Hp.* 2.

Other forms.—Fig. 19, *Plate III.*, shows a print from an unnamed track in the Edinburgh collection, which appears to be completely identical with the form *x*5 from

Mansfield (*Plate I., Fig.* 4). The impressions of pes and manus are indistinguishable, and in all the impression of digit V. is absent. In the single Mansfield print there is a doubt about this digit. Certainly a digit exists in the position shown in *Fig.* 4, but unfortunately it is mixed up with another small footprint, and it is not impossible that it may really belong to that print.

The prints in this Edinburgh track are closely set, with the right and left sides well separated.

Fig. 16, *Plate III.*, shows a print of $\times 4$ from this locality. This impression is deeper than the one from Mansfield; hence the "sole" is marked to some extent and the claws appear longer. Otherwise the prints are identical. The impressions form a normal track with short stride, and no apparent difference between the marks of pes and manus. Specimen in Edinburgh collection.

Actibates triassae, Jard., is a very unsatisfactory, but very distinctive footprint, which is sufficiently illustrated by *Fig.* 24, from Jardine's plate *IV.* Each print consists of 2 to 4 round or irregular impressions, most characteristically of 3, forming a triangle. The most remarkable feature is the great variability of the impressions. Without further comment, this track may be left for future reference with the designation *Ab.* 1.

Several other tracks are figured and named by Jardine which cannot be properly characterised, though they are useful for reference.

Chelichnus titan, Jard., is a large print, 9 or 10 inches in length, and about the the same in breadth. Successive prints separated only by 7 or 8in. Width across entire track $2\frac{1}{2}$ feet. (Jard., '53, p. 10). A specimen is in the Edinburgh collection.

Chelichnus gigas, Jard. Large oval impressions about

5 to 5·5 inches long, by 4·8 broad. Successive prints separated by about 16 inches. No indication of the digits. Track comparatively narrow. (Jard., '53, plate *I.*).

Chelichnus plagiostopus, Jard. A track of very closely set impressions. Each impression probably consisted of an obliquely set line of digits only. They are all covered with matrix. Track wide compared with the short stride. (Jard., '53, plate *X.*).

Harkness described and named a number of impressions, but did not figure them. (Hark., '51).

Chelichnus plancus, Hark., is a little chelichnoid print, only $\frac{3}{4}$ inch across the pes, with a tiny manus $\frac{1}{4}$ inch broad nearly covered by the pes, from Locherbriggs, Craigs, and Green Mill quarries. It would seem to fall near *Cl.* 3. (*Plate III., Fig.* 22).

Batrichnus Stricklandi, Hark., differs from *Cl.* 3 chiefly in size, the pes being usually under 1 inch in length. Green Mill Quarry.

Saurichnus acutus, Hark., appears to be almost exactly like a small *x*4 (*Plate III., Fig.* 16), with the "sole" fairly well impressed in some cases, but usually slight. Entire print slightly under 1 inch long. It cannot be far from *x*3 (*Plate I., Fig.* 3). Green Mill quarry.

Chelichnus obliquus, Hark., appears to be a small chelichnoid form, with prints about $\frac{1}{2}$ inch broad, inclined slightly outwards on the track, and with a stride of about 8 inches. Green Mill quarry.

Chelaspodus Jardini, Harkness, appears to agree in some respects with Actibates, but is slightly smaller, with the prints still more closely set in the track. It usually shows four marks in each print.

I am not aware that any other "species" have been published for Dumfriesshire.

Age of the Dumfries Footprints.—Nine distinct types of impression are here figured, while as many more certainly exist which are too imperfect for complete specification or have never been figured. The argument from negative evidence, that among these types there is not one that can be identified with the still larger number of known British Triassic prints (see Beasley, :03—:08), is strong against the Triassic age of these strata. It is much strengthened by the fact that the principal types of Triassic prints are represented by identical forms from several Triassic localities. Thirdly, the whole *facies* of the Dumfries prints differs from that of the Triassic series. On the other hand, out of five types of impression from Mansfield here figured, two appear to be identical with Dumfries forms, while I am convinced that the number of coincidences may be readily increased. In both localities, impressions of the "Chelichnoid" type are dominant. Finally, though no exact coincidence between the Penrith prints and those from Dumfries can yet be shown, the general *facies* is again in close agreement (*cf.*, *Plate II.*, *Fig.* 13, with *Plate III.*, *Figs.* 20*b* and 21*b*). These facts appear to me practically conclusive in favour of the Permian age of the Dumfries strata. It is interesting to note that Harkness identified some of the Penrith prints as *Chelichnus Duncani.* (Hark., '62, p. 218.)

The Elgin Footprints.

These tracks, first noticed by Captain Lambart Brickenden (Brickenden, '52), were subsequently described by Huxley (Hux., '59 and '77). In the Elgin district

tracks have now been obtained from the Cummingstone quarries and Bishop Mill quarry, and doubtful ones from the Nairn quarries (Gordon, '93), but only the Cummingstone ones have been described.

Chelichnoid Forms.—Chelichnus megacheirus, Hux., is shown in *Plate II., Figs. 6m*, *6p*, and *6b*. Huxley regarded the larger prints as those of the manus, but in this I think he was misled by their position in the track. This form appears to be closely allied to *Cl. 7* from Mansfield (*Plate I., Fig.* 1). There was one print from Mansfield, which has unfortunately been mislaid, which showed the correspondence much more closely. In the Mansfield form the larger print is certainly that of the pes. In both tracks, the larger prints are not quite so widely separated laterally as the smaller ones. Both forms appear to have been webbed. Huxley remarked that the Dumfries prints were the only ones with which this form could be compared. It may be termed *Cl.* 5.

The track figured by Brickenden (*loc. cit.*) is a typical small chelichnoid track, which may be matched perfectly by some of the tracks from Penrith. Unfortunately all the individual prints are imperfect.

Unclassified form.—Figs. 7 and 8, from Huxley's plate *XV.* (Hux., '77), indicate a print which is clearly allied very closely to *x*2 (*Plate II., Fig.* 9) from Penrith, and to *x*3 (*Plate I., Fig.* 3) from Mansfield. The manus in this form is probably not so small relatively to the pes as would at first sight appear. Behind the proper print in *Fig.* 7 is shown a blurred impression which in Huxley's figure might at first sight be taken for a part of this print. I have no doubt that it is really a pair of imperfect impressions accidentally juxtaposed, but lest there should be any

doubt I added *Fig.* 8, which clearly represents the same form, and in which there is nothing of the sort.

Age of the Cummingstone beds.—Small as the published evidence of the footprints from this locality is, I think its indication is clear. Of the close relationship of *Cl.* 5 with the Mansfield forms I am convinced. *x*1 may be matched both at Mansfield and Penrith, while Brickenden's track is a typical Penrith form. Adding the absence of any suggestion of Triassic forms, the evidence could scarcely be more emphatic in favour of the Permian age of these footprint beds. This evidence is corroborated by a recent paper by my friend Mr. D. M S. Watson, in which he points out that the beds containing *Gordonia Geikie* and *Elginia*, are distinct from those containing the remaining Elgin reptiles, and that the forms named are distinctly of Permian rather than Triassic affinities (Watson, :09). There is unfortunately no direct evidence as to the relation of the footprint beds to any of the reptiliferous deposits.

The establishment of true Permian in this area, is a fact of unusual interest as going not a little way towards lessening the discrepancy of the stratigraphical and palæontological evidence as to the relations of the "Old" and "New" Red Sandstones.

The quarries of Bishops Mill and Nairn, from which footprints are also recorded, are in accepted Upper Old Red. In confirmation of these occurrences, we have the undoubted footprints of Tarbartness, which are in beds which have never been separated from the Upper Old Red. Unfortunately, I have not seen any of these impressions, and no account of them is published, but I believe a careful examination of them, might go far towards settling the long-standing enigma of the rocks in this part of Scotland.

The Devonshire Footprints.

I do not intend to give any description of the prints which have recently been discovered by Principal Clayden in the Red Sandstones near Exeter, as they are under full investigation by their discoverer. They are illustrated only by *Fig.* 15, *Plate II.*, drawn from Mr. Clayden's plate (Clayden, :08). The resemblance of this track to some of those from Penrith is obvious. Mr. Clayden hopes to settle the age of these beds by means of the footprints, and I have little doubt they will prove to be a Permian group, thus confirming the opinion now generally entertained, concerning the correlation of these rocks.

Relation of the Permian Footprints to those of the Trias and Carboniferous.

The comparison with Triassic footprints can be very briefly disposed of. I have never yet seen any Permian print which could be confused with a Triassic one. What is more significant, the whole *facies* of the two sets of impressions is distinct. In the Permian, impressions of a plantigrade type are decidedly the rule; in the Trias they are rare—a fact not without its palæontological interest. In the Permian again, "wide" tracks (*i.e.*, with right and left sides well separated) are the predominant type, while the Triassic forms tend to have the sides more approximated—again a feature of both palæontological and stratigraphical interest. There is no well-defined Permian track yet known which has the characteristic feature of all the cheirotheroid forms: the prints of the right and left sides nearly in a line.

The relation of the Permian and Carboniferous footprints promises to be interesting. Unfortunately no

well-defined British Carboniferous prints have yet been described, though there is little doubt they exist. Mr. Barkas referred to a find of good prints in the Lower Carboniferous, near Otterburn, Northumberland, at the British Association meeting at Newcastle-upon-Tyne, but I have not been able to find any published account of them (Barkas, '89). In the same year Mr. John Smith published a description of a track of imperfect prints from the Calciferous Sandstone, near West Kilbride, Ayrshire (Smith, J., '89). The track is very like some of the Permian ones, but more cannot be said. The same gentleman is at present, I believe, engaged in an account of further discoveries in the same rocks. There is in the Manchester Museum a remarkable track from the Millstone Grit of Tintwistle, Cheshire, described by Mr. Binney, and named by him *Chelichnus ingens* (Binney, '56). It is again too imperfect for comparison. A more perfect track was described by Haines from the Millstone Grit of Kilrush, Co. Clare, but in the absence of figures the description is insufficient (Haines, '52). The foregoing examples show at least that we may hope for more satisfactory material if it is looked for.

The North American Carboniferous rocks have yielded quite a number of excellent tracks. *Plate IV.* is devoted to some of these, together with some of the prints from the Rothliegende of Thüringia. A comparison of *Fig.* 27 (*Ichnium gampsodactylum*, Pabst, from Friedrichroda, Thüringia) with *Fig.* 31 (*Dromopus agilis*, Marsh, from Coal Measures of Kansas), shows at once a remarkable resemblance. From a careful examination of the original figures, I believe the two forms are really almost identical, and may be taken as indicating the presence of very closely allied animals. (Pabst, :05, and Marsh, '94*a* and '94*b*). Similarly a marked resemblance exists between *Fig.* 25*b*.

(*Ichnium sphaerodactylum*, Pabst, from Tambach, Thüringia), and *Fig.* 33 (*Baropus lentus*, Marsh, from the Coal Measures of Kansas). It is interesting to note here that Mr. Varty Smith has obtained from the "Yoredale" Sandstone, near Penrith, a print which closely resembles the *Ichnium sphaerodactylum*, when that print is preserved so as to show only the tips of the digits.

The remaining figures on *Plate IV.*, should be useful for future comparison. Meanwhile it seems clear, that the relationship of the Permian series of footprints is likely to prove much closer with those from the Carboniferous, than with the Triassic forms—a fact quite in keeping with the general relationships of the Carboniferous, Permian and Triassic faunas.

The present communication is necessarily of a preliminary character, and is mainly put forward with a view to stimulating future research, and to show that fossil footprints are worthy of more than summary dismissal with a quotation from Longfellow.

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EXPLANATION OF PLATES.

All figures of individual prints in Plates I., II., and III. are exactly $\frac{1}{2}$ natural size.

Figures of individual prints in Plate IV. are $\frac{1}{4}$ natural size.

The figures are all accurate outlines of single impressions, except Fig. 9, Plate II., figs. 18 and 22, Plate III. and fig. 25, Plate IV., which are slightly restored by a careful comparison of several prints.

PLATE I.

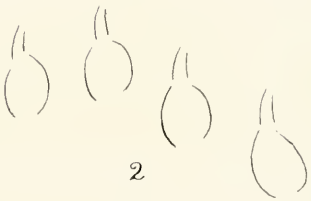
Footprints from the Permian of Mansfield, Notts.

Fig. 1	= *Cl.* 7	× $\frac{1}{2}$.	See page 2.
	1*m* = right manus.	1*p* = right pes.	1*b* = track × $\frac{1}{13}$.
Fig. 2	= *x*4	× $\frac{1}{2}$.	See pages 3 and 10.
Fig. 3	= *x*3	× $\frac{1}{2}$.	See pages 3 and 5
Fig. 4	= *x*5	× $\frac{1}{2}$.	See pages 4 and 9.
Fig. 5	undescribed print	× $\frac{1}{2}$.	See page 4.

1m

1b

1p


2

5

4

PLATE II.

Figs. 6, 7, 8. Footprints from Cummingstone, nr. Elgin.

Figs. 9 to 14. Footprints from Permian of Penrith.

Fig. 15. Footprints from near Exeter.

Fig. 6. = *Cl.* 5 (*Chelichnus megacheirus*, Huxley) $\times \frac{1}{2}$.

$6m$ = right manus. $6p$ = right pes. $6b$ = track $\times \frac{1}{12}$.

See page 13.

Figs. 7 & 8. = $x1$ $\times \frac{1}{2}$. See page 13.

Fig. 9. = $x2$ $\times \frac{1}{2}$. See page 5.

Left pes and manus in natural relation.

Figs. 10 & 11. = *Cl.* 6 $\times \frac{1}{2}$. See page 5.

Fig. 12. = *Hp.* 3, $\times \frac{1}{2}$. See Note, page 5.

Fig. 13. = Chelichnoid track (? *Cl.* 6) $\times \frac{1}{6}$. See page 4.

Fig. 14. = *Lc.* 1 $\times \frac{1}{2}$. See page 5.

Fig. 15. Track from Lower Red Sandstones, Exeter. See Clayden, :08.

6p
6m
7
8
6l

9
10
11
14
12
13

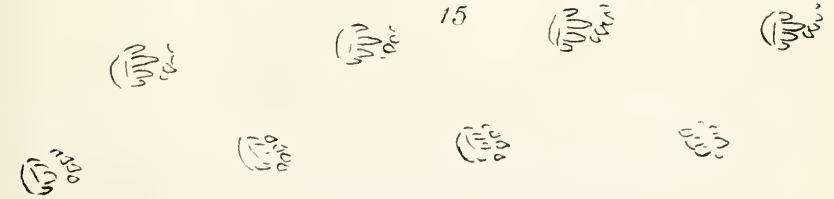

15

PLATE III.

Footprints from the Red Sandstones of Dumfriesshire.

Fig. 16. = *x*4 × ½. See pages 10 and 3.

Fig. 17. = *Hp.* 1 (*Herpetichnus sauroptesius*, Jardine) × ½. See page 8.
17*m* = manus. 17*p* = pes (prints *not* in natural relative position).

Fig. 18. = *Cl.* 4 (*Herpetichnus Bucklandi*, Jardine) × ½. See page 8.
(Manus and pes in approximately correct relative positions.)

Fig. 19. = *x*5 (unnamed print, Edinburgh collection) × ½. See pages 9 and 4.
Right side.

Fig. 20. = *Cl.* 1 (*Chelichnus Duncani*, Owen sp.) × ½. See page 6.
Right pes. Mound of sand to rear not fully shown.
20*b*. Track of same × $\frac{1}{10}$.

Fig. 21. = *Cl.* 2 (*Chelichnus ambiguus*, Jardine) × ½. See page 7.
Right pes and manus in correct relative position.
21*b*. Track of same × $\frac{1}{10}$.

Fig. 22. = *Cl.* 3 (*Batrichnus Lyelli*, Harkness sp.) × ½. See page 7.
Left pes and manus in correct relative position.

Fig. 23. = *Hp.* 2 (*Herpetichnus loxodactylus*, Dudgeon) × ½. See page 9.
Left pes (really *cast* of right pes).

Fig. 24. = *Ab.* 1 (*Actibates triassae*, Jardine) × $\frac{1}{10}$. See page 10.
The form of each print is indicated as correctly as possible.

16
17m
18
19
17p
20
23
22
21
21b
24
20b

PLATE IV.

Figs. 25, 26, 27. Footprints from the Permian (Rothliegende) of Thüringia.

Figs. 28 to 33. Footprints from the Carboniferous of North America.

Fig. 25. = *Ichnium sphaerodactylum*, Pabst × $\frac{1}{4}$.
Left pes. 25*b*. Track of same × $\frac{1}{11}$.
Tambach, Thüringia.

Fig. 26. = *Ichnium acrodactylum*, Pabst × $\frac{1}{4}$. Left pes.
Tambach, Thüringia.

Fig. 27. = *Ichnium gampsodactylum*, Pabst × $\frac{1}{4}$.
Right pes and manus in correct relative position.
Friedrichroda, Thüringia.

Fig. 28. = *Thenaropus heterodactylus*, King × $\frac{1}{4}$. See King, '45.
Right pes and manus in approximately correct relative position.
Westmoreland Co., Pennsylvania.

Fig. 29. Print found by Logan × $\frac{1}{4}$. See Dawson, '63.
Right foot. Lower Carboniferous, Horton Bluff, Nova Scotia.

Fig. 30. Prints found by Dr. Harding × $\frac{1}{4}$. See Dawson '63.
Right pes and manus in natural relation.
Carboniferous, Parrsboro', Nova Scotia.

Fig. 31. = *Dromopus agilis*, Marsh × $\frac{1}{4}$. See Marsh '94*a*.
Left pes and manus in natural relation.
Coal Measures, Kansas.

Fig. 32. = *Sauropus primaevus*, Lea × $\frac{1}{4}$. See Lea '55.
Left pes and manus in natural relation.
Lower Carboniferous Red Shales, Pittsburgh, Pa.

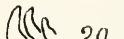
Fig. 33. = *Baropus lentus*, Marsh × $\frac{1}{12}$. See Marsh '94.
Coal Measures, Kansas.

25

26

27

25b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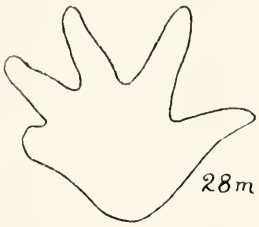
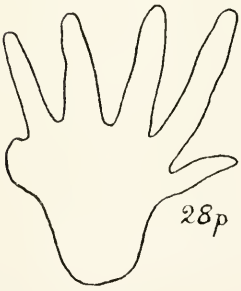
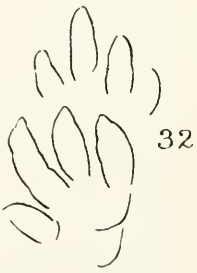
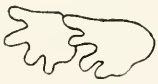

28m

31

30


28p


32



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Manchester Memoirs, Vol. liii. (1909), *No.* 23.

XXIII. The Guatemalan Earthquakes and Eruption of 1902.

By W. S. Ascoli, F.R.G.S.

(*Communicated by Mr. C. E. Stromeyer, M.Inst.C.E.*)

(*Read April 20th, 1909. Received for publication May 5th, 1909.*)

Through its situation on one of the great volcanic centres of the earth, Guatemala has suffered considerably during historical times from earthquakes and volcanic eruptions, but it is doubtful whether any year has been marked by disasters of the magnitude of those of 1902. The first disturbance of the series occurred on January 18th of that year, when the village of San Martin, near Quezaltenango, on the slopes of the Santa Maria, was partially destroyed. From that date till April 18th, everything was quiet. Then at 8-20 p.m. on that day an earthquake of great violence destroyed the town of Quezaltenango. The duration of its greatest intensity was 57 seconds. Two distinct phases were clearly noticeable—the first, which lasted about 25 seconds, marked by heavy undulations (causing but little damage to buildings), and the second, consisting of a succession of great vertical jolts, following each other with great rapidity, which completely destroyed the town. So violent were these jolts that the plant at the electric generating station was overturned and the town was plunged in complete darkness. Though many of the houses were built of stone, few escaped severe injury, and all were condemned as uninhabitable by the authorities.

May 18th, 1909.

The most utter confusion followed the disaster, for shocks followed each other with great rapidity, and the terrified populace were in constant dread that worse might still follow. Out of a population of 20,000, the number of dead was nearly 1,400. Had the shock occurred a few hours later instead of at a time when people were taking their evening stroll, few would have escaped with their lives.

I was living in the town at the time of the disaster, and, being in a first floor room which collapsed entirely, had a very narrow escape. Moreover, for many reasons, I was unable to leave the ill-fated town for a week after April 18th, and consequently had full opportunity for seeing what havoc such a shock can cause.

Owing to its isolated position in the heart of the mountains, and to the superstitious dread of the Indians, who supply the market, the town was totally deserted and cut off from the outer world for several days. In addition to other privations, the poorer inhabitants suffered greatly from hunger. Though efforts were made to recover the dead and to alleviate the sufferings of the wounded and destitute, little could be done on account of the magnitude of the disaster and the few available hands.

The centre of the disturbance seems to have been the Santa Maria, for, in addition to Quezaltenango, most of the buildings on the coffee estates on the southern slopes of the volcano were completely wrecked. The town of San Pedro to the W. of Quezaltenango was also destroyed.

During the week following the great earthquake, shocks were of great frequency, and continued for some six weeks. Quiet reigned again during June, July, and August. Then on September 23rd an earthquake of the oscillating type, of great force and duration, shook the

country. From that date till the day of the eruption —October 24th—shocks were again very frequent, and, as the day in question approached, became almost incessant.

The scene of the eruption (*Plate I., Fig.* 1) was the Santa Maria, a volcano situated a few miles to the south of Quezaltenango. Previous to this, there was not even the slightest sign of activity, though the neighbouring Cerro Quemado was in violent eruption about 100 years ago, and still has a fairly active, open crater. From personal knowledge, I can state that the old crater on the summit, about 12,000 ft. above sea level, was totally extinct, consisting merely of a shallow, rocky depression, mostly overgrown. The slopes, from base to summit, were covered with a thick forest, many of the trees being of great size.

On the afternoon of October 24th, 1902, a column of steam was seen to issue from the southern slopes at a height about 6,500 ft. above sea-level. With great rapidity this increased in violence, and by nightfall the new crater was in full eruption. During 72 hours, paroxysms followed each other with ever-increasing fury, during which time the surrounding country, within a radius of many miles, was plunged in complete darkness. So violent were the detonations, that they were clearly audible in Costa Rica, more than 500 miles distant.

The devastation, some of which is shown in *Plate II.*, was immense. All that tract of rich tropical vegetation and coffee-land, lying between the volcano and the Mexican frontier, over 600 square miles in extent, was converted into a desert of white ash and sand. The total area covered by the ejecta was about 125,000 square miles, and the cloud issuing from the crater was measured to be about 18 miles in height.

The new crater (*Plate I., Fig.* 2) measures about

$\frac{7}{8} \times \frac{3}{4}$ mile, and has a present depth of some 1,500 feet. The whole of the side of the mountain above this and up to the summit was completely blown out during the first three days of the eruption, leaving an almost vertical cliff, 7,000 feet in height, exposed. Though still in a state of considerable activity, no further damage was caused. The seat of activity at present is a small hot lake in the S.E. corner of the crater. From the side of this a great steam jet, of considerable violence, issues, alternating horizontally and vertically.

I have frequently visited the scene of the eruption both before and after the events described above. I have ascended the Cerro Quemado many times, and the Santa Maria once, before the earthquake of April 18th. Since the eruption I have also visited both. At the end of 1902, and the beginning of 1903, I made three attempts to reach the new crater, none of which, however, was entirely successful, owing chiefly to the state of the new ash. But in January, 1907, accompanied by Dr. Tempest Anderson, of York, I reached the crater, and some observations of considerable interest were made.

EXPLANATION OF PLATES.

Fig. 1, *Pl. I.*

ERUPTION OF SANTA MARIA. October 24-27th, 1902.

Photo taken from Quezaltenango (protected) side at the first sign of daylight: on the further side the darkness was complete till sunset on the 27th. The new crater is situated low down on the further side of the cone, to the protection of which Quezaltenango owed its safety.

Fig. 2, *Pl. I.*

INTERIOR OF NEW CRATER OF SANTA MARIA. January, 1907.

The middle-distance shows southern crater-wall (about 1,500 ft. high), with hot lake and steam jet at base. The devastated slopes in the background—in the direction of the Mexican frontier—were formerly covered with rich vegetation. The cone of the Santa Maria rises to the right of the picture: to the left some 40 miles distant is the Pacific Ocean.

FIG. 2.

FIG. 1.

Plate II.

LOWER SLOPES OF SANTA MARIA. January 1903.

This area was formerly covered by a thick forest. The photo shows clearly the early work of erosion by water on the new ash : a year later these channels were converted into small ravines, rendering access to the crater difficult. In the background is seen the S.E. lip of the crater, with steam rising from below. It was from the summit of this lip (about 1 inch from the right-hand side of photo) that the view of the interior (*Pl. I., Fig.* 2) was taken.

XXIV. Geographical Distribution of Birds. (Genus *Macronyx*, Swainson.)

By Francis Nicholson, F.Z.S.,

Member of the British Ornithologists' Union, Corresponding Member of the American Ornithologists' Union, &c., &c.

Received and read November 17th, 1908.

A few years ago I had determined to write a monograph of the Motacillidae (Wagtails and Pipits), and for the purpose I made a large collection of these birds. The publication of the tenth volume of the "Catalogue of Birds in the British Museum" seemed to take away the necessity for my intended "Monograph," so I abandoned the project, and dispersed my collection. In this I may, or may not, have been wise, but the completeness of Dr. Bowdler Sharpe's work in the "Catalogue" seemed to leave me little to say.

I have, however, a mass of notes on Pipits and Wagtails in my possession, the result of several years' work, and it has occurred to me that it might be interesting to publish these in the form of papers on geographical distribution, a subject that has always interested me. New collections are continually arriving, and new facts becoming known, rendering the most elaborate works, like those of Reichenow and Shelley, incomplete, as will be seen in this small essay, which is written to bring up to date the geographical memoranda on the genus *Macronyx* detailed by these celebrated ornithologists.

Macronyx is a purely Ethiopian genus, being confined to the African continent, where the species are popularly

known as 'Long-claws,' from the unusual development of the claw of the hind toe.

The species may be divided into two sections, those with a yellow or orange breast, and those with a pink breast. The most widely distributed is *M. croceus*, which belongs to the former section, and is found over the greater part of Africa. The range of some of the others is more confined, being as follows :—

West African	Sub-Region,	*M. croceus.*
South	„	*M. croceus.*
„	„	*M. ascensi.*
„	„	M. CAPENSIS.
„	„	M. AMELIAE.
East	„	*M. wintoni.*
„	„	M. AURANTIIGULA.
„	„	*M. croceus.*
„	„	*M. ascensi.*
„	„	M. FÜLLEBORNI.
Equatorial	„	M. SHARPEI.
„	„	*M. wintoni.*
„	„	*M. croceus.*
Abyssinian	„	M. FLAVICOLLIS.
„	„	*M. croceus.*

In the above note on the geographical range, the name of a species in small capitals indicates that it is peculiar to that particular Sub-region.

No. 1. capensis.	No. 5. ascensi.
„ 2. flavicollis.	„ 6. aurantiigula.
„ 3. croceus.	„ 7. sharpei.
„ 4. fülleborni.	„ 8. ameliae.

No 9. wintoni

1. Macronyx capensis.

Macronyx capensis (Linn.), Sharpe, "Cat. B. Brit. Mus.," vol. 10, p. 623 (1885); Shelley, "B. Africa," vol. 3, p. 2 (1902); Reichen., "Vög. Afrikas," vol. 3, p. 320 (1904).

Macronyx capensis colletti, Schou, *Orn. MB.*, 1908, p. 119.

Hab. The higher "veldt" region of Natal, the Orange Free State, and Transvaal, ranging into Matabele Land and Mashoona Land (Stark, "Faun. S. Afr. Birds," vol. 1, p. 238). Cape Colony, Cape Town (*C. J. Andersson*, "Mus. Brit."; Sharpe, "Cat. Afr. B.," p. 73, 1871). Knysna, May, Nov. (Grill, "Zool. Anteckn.," p. 25, 1858). Abundant on the high plateau above Knysna (Layard, "B. S. Afr.," p. 121, 1867). Karroo, Dec. to Feb. (Grill, "Zool. Anteckn.," p. 25, 1858): rare in the Karroo (Stark, "Faun. S. Afr. Birds," vol. 1, p. 238). Orange River (between Aliwal North and Norval's Pont). Not common in summer, but becoming very abundant in late autumn and winter: first saw a pair on Jan. 9th (Whitehead, *Ibis*, 1903, p. 226.) East London and Port Elizabeth (*Rickard:* Sharpe, ed. Layard, "B. S. Afr.," p. 530). Eland's Post (*T. C. Atmore:* Sharpe, ed. Layard, "B. S. Afr.," p. 530). Kingwilliamstown (*Trevelyan:* Sharpe, "Cat. B. Brit. Mus.," vol. 10, p. 623). Windvogelberg (*Bulger:* Sclater *P.Z.S.*, 1866, p. 23). Natal (*Ayres:* Gurney, *Ibis*, 1860, p. 208). Durban (Shelley, *Ibis*, 1875, p. 73). Pinetown, Jan., Feb. (*T. L. Ayres:* Sharpe, "Cat. B. Brit. Mus.," vol. 10, p. 623); between Ladysmith and Newcastle, May: Pretoria, Dec. (*F. Oates:* Sharpe in Oates' "Matabele Land," app., p. 317). Ingagane River, Oct., Nov. breeding (Butler, Fielden, and Reid, *Zool.*, 1882, p. 335). Zulu Land (R. B. and J. D. S. Woodward, *Ibis*, 1897, p. 412). Eschowe (*Woodward:* Sharpe, *t.c.*, p. 514). Sibudeni, 20 miles N.W. of Eschowe, Oct., Nov.

(*Claude Grant:* Mus. Brit.). Orange River Colony. Kroonstadt; plentiful all over the district (Symonds, *Ibis*, 1887, p. 333). Winburg and Kroonstadt districts (*Holub: cf.* Holub and Pelz., "Orn. Südafr.," p. 86). Transvaal. Potchefstroom, May, Aug., Oct. (*Ayres:* Mus. Brit.). Plentiful at the Goldfields as in all other parts of the Transvaal (Ayres, *Ibis*, 1873, p. 282, 1876, p. 426). Makalaka Country (*Bradshaw:* Mus. Brit.). Matabele Land (Holub and Pelz., "Orn. Südafr.," p. 86). Mashona Land. Everywhere distributed, but nowhere plentiful (Guy Marshall, *Ibis*, 1900, p. 238). Inshlangeen River (*Jameson*), Matje Umschlope, Nov.; common (Shelley, *Ibis*, 1882, p. 350).

In the *Ornithologische Monatsberichte* for 1908 (vol. 16, p. 119), Mr. Schou has described a race from Zulu Land as *Macronyx capensis colletti*, and says that in this form, the yellow colour of the under surface reaches right up to the black ring which encircles the reddish yellow of the lower neck; it has, moreover, a generally clearer yellow streak above the eye, and a tuft of yellow feathers below the latter, the yellow edge of the wing being strongly marked.

Professor Neumann has examined the series in the British Museum, and confirms the characters which Mr. Schou gives for his sub-species, which is said to inhabit Natal, Zulu Land, Orange River Colony, and the Transvaal, while the true *M. capensis* is supposed to be confined to the southern districts of Cape Colony.

Dr. Bowdler Sharpe and I have together gone through the series of *Macronyx* in the British Museum, and neither of us can perceive the distinctions which Mr. Schou claims for his *Macronyx*. I fear that *M. colletti* must be considered a synonym of *M. capensis*.

2. Macronyx flavicollis.

Macronyx flavicollis, Rüpp., "N. Wirb. Vög.," p. 102, pl. 38, fig. 2 (1835); *id.*, "Syst. Uebers.," p. 79 (1845); Shelley, "B. Africa," vol. 3, p. 11 (1902); Reichen., "Vög. Afrikas," vol. 3, p. 324 (1904).

Hab. Common on the Highlands of Abyssinia (Rüppell, *l.c.*). High Plateau of Semien, Wogara and Begemeder, 8,000 — 10,000 feet (Heuglin, "Orn. N. O. Afr.," vol. 1, p. 330). Wadala Plateau, "only seen on the highest part of the Dalanta Plateau, and near the crest of the Wandaj Pass: never observed below 10,000 feet" (Blanford, "Geol. and Zool. Abyss.," p. 384). Jifadensa, S. Abyssinia, Jan. 22; Balti, Jan. 23 (Weld-Blundell and Lovat, *Ibis*, 1900, p. 142); Jifadensa, S. Abyssinia, Dec. 28; Adis Ababa, Jan. 2nd. Common over the higher plateau (*A. E. Pease;* Grant and Reid, *Ibis*, 1901, p. 633). Dembretcha, Gamot in Godjam (*Degen:* Grant, *Ibis*, 1904, p. 263). Woddeccia, Shoa; Adda Galla, June; Rugghie; Valley of Woddeccia, June (Salvad., *Ann. Mus. Genova* (2), vol. 1, p. 169, 1884); Antoto, Shoa, Nov., Dec.; Fallè, Jan. (*Ragazzi:* Salvad., *op. cit.*, vol. 6, p. 265, 1888). Entotto, Nov., Dec.: Albaso, Arusi Galla (*Traversi:* Giglioli, *Ann. Mus. Genova* (2), vol. 6, p. 35, 1888). Aveve, Province Kollu, Shoa, Sept.; Abuje and Badattino, Province Gindeberat, Shoa, Sept., Oct.; Abera in Djamdjam, Dec.; Gardulla, Jan.; Djala in Gofa, Jan.; Bola Goschana in Doko, Feb.; Schubba in West Kaffa, Feb., April (Neumann, *Journ. f. Ornith.*, 1906, p. 237).

3. Macronyx croceus.

Macronyx croceus (Vieill.), Sharpe, "Cat. B. Brit. Mus.," vol. 10, p. 623 (1885); Shelley, "B. Africa," vol. 3, p. 4 (1902); Reichen., "Vög. Afrikas," vol. 3, p. 321 (1904).

Hab. Nearly the whole of Africa, below the Sahara, and to the southward of 20° N. Lat.

WEST AFRICA. RIVER GAMBIA. (Mus. Brit.; Mus. Brem.; *cf.* Sharpe, "Cat. Afr. B.," p. 73). Casamance (*Verreaux:* Hartl., "Orn. W. Afr.," p. 73). SIERRA LEONE (*Verreaux:* Hartl., *l.c.*), Bo, Sept., Oct., Jan., Feb.; not numerous (Robin Kemp, *Ibis*, 1905, p. 237). LIBERIA, Robertsport (Demery), Marfa River, Grand Cape Mount River (*Büttikofer* and *Sala:* Büttikofer, *Notes Leyden. Mus.*, vol. 7, p. 174, 1885): Paynesville (*Stampfli:* Büttik., *Notes Leyden. Mus.*, vol. 8, p. 253, 1886). GOLD COAST. Common in all parts (Ussher, *Ibis*, 1874, p. 70). Fanti Country (*Shelley, Kirby:* Mus. Brit.): sea-shore, near Elmina, April (H. F. Blissett); Accrà (*G. E. Shelley* and *T. E. Buckley:* Mus. Brit.): (Reichen., *Journ. f. Ornith.*, 1875, p. 46): Aguapim (*Riis.:* Hartl., "Orn. W. Afr.," pp. 73, 271). Togo Land. River Volta (*Ussher:* Sharpe, *Ibis*, 1870, p. 481: *id.*, "Cat. Afr. B.," p. 73, 1871). NIGERIA, Shonga (*W. A. Forbes:* Shelley, *Ibis*, 1883, p. 543). Gaboon (*Verreaux:* Hartl., "Orn. W. Afr.," pp. 73, 271), Cape Lopez (*Du Chaillu:* Cassin, *P. Acad. Philad.*, 1856, p. 307). Fernand Vaz (*Marche:* Bouvier, "Cat. Marche Coll.," p. 16, 1875). Loango Coast (*Falkenstein:* Reichen., *Journ. f. Ornith.*, 1877, p. 30). LOWER CONGO: Landana, Chinchonxo (*Petit:* Sharpe and Bouvier, *Bull. Soc. Zool. France*, 1876, p. 43): ANGOLA, Cambambe (Monteiro, *Ibis*, 1862, p. 334): Benguela, Huilla, Humbe Ambaca, Caconda, (*Anchieta:* Bocage, "Orn Angola," p. 297).

SOUTH AFRICA. Extends as far south as Natal, but is rarely found in Cape Colony (Stark, "Faun. S. Afr. Birds," vol. 1, p. 239). Pondo Land. Resident and plentiful at St. John's, in flat open country (Shortridge, *Ibis*, 1904,

p. 179). NATAL (*Ayres:* Gurney, *Ibis*, 1860, p. 208): Durban (*Gordge:* Shelley Coll.): Pinetown, Jan. to Nov. (*T. L. Ayres: G. E. Shelley:* Mus. Brit.); common (Shelley, *Ibis*, 1875, p. 73). ZULU LAND. Santa Lucia Lake (R. B. and J. D. S. Woodward, *Ibis*, 1900, p. 524). Insusie Valley, 20 miles N.W. of Eschowe, Dec. 8, 1903; Umfolosi Station, June to Sept. 1904: Nyoye Forest, Sept. 25, 1904 (*Claude Grant:* Mus. Brit.). TRANSVAAL. Lydenburg district, seen from Bloemfontein up to Pretoria and Nazareth, and on a trip to Rustenberg (Barrett, *Ibis*, 1876, p. 208); Barberton District (Rendall, *Ibis*, 1896, p. 174), Legogot, Barberton District, May 3-16, 1906 (*Claude Grant*). Gaza Land. Abundant everywhere in the open grass country (Swynnerton, *Ibis*, 1907, p. 40). Chirinda Forest, Feb. (*D. M. Stanley*, Mus. Brit.). PORTUGUESE S. E. AFRICA. Inhambane (Sclater, *Ibis*, 1899, p. 112, *Francis*); Cogunho, Inhambane, June 29, 1906 (*Claude Grant:* Mus. Brit.). Barratas, near Beira (H. S. H. Cavendish; Sharpe, *Ibis*, 1900, p. 111). Mesenbeti, 23 miles N.W. of Beira, Nov. 9, 1906 (*Claude Grant:* Mus. Brit). Beira, Nov. 22-26, 1906, Feb. 10, 1907 (*Claude Grant:* Mus. Brit.). Zambesi. Abundant on the sea coast of the Delta (Kirk, *Ibis*, 1864, p. 318). Nyasa Land. Zomba plains, Dec., Jan. (A. Whyte: coll. *Sir H. H. Johnston*); Tschiromo, Sept. (A. Whyte: coll. *Sir H. H. Johnston*). Liwonde, Namaramba, Aug. Mtondwe, June. Kasungu, Oct. N. Nyasa Land, Sept. S. Angoni Land, Aug., Sept. (*Sir A. Sharpe:* Shelley, *Ibis*, 1898, pp. 379, 553).

EAST AFRICA. Zanzibar coast (*Hildebrandt*; Cab., *Journ. f. Ornith.*, 1878, p. 220). Mtoni, near Zanzibar (*Bohndorff:* Mus. Brit.). Usambara Hills: Dar-es-Salaam (*Sir J. Kirk: F. Buxton:* Shelley, *P.Z.S.*, 1881, p. 573:

Nicholson, *P.Z.S.*, 1878, p. 356): Kitui, Ukamba (Hildebrandt; Cab., *Journ. f. Ornith.*, 1878, p. 220). Machako's (*F. J. Jackson: S. L. Hinde:* Mus. Brit.). Lindi, Bagamojo, Usaramo, Maurui, Paré, Arusha Galla country, Wapokomoland, Lamu, Barawa (Fischer, *Journ. f. Ornith.*, 1885, p. 137). Along the coast from Witu to Mombasa, and throughout the two Protectorates westward to Uganda (Jackson, *Ibis*, 1905, p. 101).

EQUATORIAL AFRICA. Nairobi, Nov.; Molo River, Jan.; Gessima River, Likipia, Jan.; Msara, N. E. Kenia, Feb. (Delamere Coll.: Mus. Brit.). Particularly plentiful in the Nandi country, at an altitude of 6,500 feet, and again at the Eldoma Ravine, and on the eastern foot-hills of Mau. Breeds in Nandi, from April to June: also breeds near Entebbe in Uganda (Jackson, *Ibis*, 1905, p. 101). W. Uganda (*J. T. Cunningham:* Mus. Brit.) Kazi, Uganda (*F. J. Jackson*). Mabira Forest (C. Christy). Mruli: Kafu River in Unyoro: Usoga country (*Ansorge:* Hartert in Ansorge, "Afr. Sun.," App., p. 348). Mangiki, Mt. Elgon (*F. J. Jackson*). Albert Edward Nyanza (*Scott-Elliot:* Mus. Brit.). Muggi, Nov. (*Emin Pasha:* Mus. Brit.: Hartl., *Abhandl. Nat. Ver. Bremen*, vol. 7, p. 99, 1881). Kiri, May (*Emin Pasha:* Mus. Brit.). Gazelle River (Antinori, "Cat. descr. Ucc.," p. 41 (1864): Heugl., "Orn. N. O. Afr.," vol. 1, p. 331).

4. Macronyx fülleborni.

Macronyx fülleborni, Reichen., *Orn. MB.*, vol. 8, p. 39 (1900): Shelley, "B. Africa," vol. 3, p. 9 (1902): Reichen., "Vög. Afrikas," vol. 3, p. 322 (1904).

Hab. Unyika Highlands to the north of Lake Nyasa, Tandala and Mararupia (*Fülleborn:* Reichen., *l.c.*), Ngomingi (*V. Marwitz*), Songea (*Booth*). *Cf.*, Reichen., *l.c.*

5. Macronyx ascensi.

Macronyx ascensi, Salvad., *Boll. Mus. Torino*, vol. 22, No. 570, p. 6 (1907).

Hab. Luconzolwa, W. of Lake Moero, to the S.W. of Lake Tanganyika (*Ascenso:* Salvad., *t.c.*). Upper Lualaba River, May 16, 1907 (*S. A. Neave*). Caconda, Benguela, Dec. 4, 1901 (*C. H. Pemberton:* Mus. Rothschild): Kamesgori, 3 days' march from Pango Andongo, Angola, July 21, 1903 (*W. J. Ansorge:* Mus. Rothschild).

I have examined the type of *M. ascensi* which was kindly sent over to England by Count Salvadori, and I was enabled to compare it with an example of the true *M. fülleborni* from Ngomingi, received by the Tring Museum from the Berlin Museum, and identified by Dr. Reichenow. The differential characters of the two forms were as pointed out by Dr. Reichenow, and I follow him in keeping them distinct. At the same time, the differences between *M. ascensi* and *M. fülleborni* are extremely slight, and I imagine that when a larger series is available, we shall find that the species are not separable. This is the more probable from the evidence of their geographical distribution, so far as is known at present. This species is said by Count Salvadori to resemble *M. croceus*, but to differ in the tint of the yellow under surface, which is more chrome than lemon-yellow in appearance. The absence of streaks on the flanks is another character. In this respect it approaches *M. fülleborni* of Dr. Reichenow, to whom Count Salvadori sent his specimen for comparison. Dr. Reichenow came to the conclusion, after comparing the type of *M. ascensi* with that of *M. fülleborni*, that the two species were not identical, and that *M. ascensi* was to be distinguished by the greyer colour of the rump and upper tail-coverts, which had, moreover, no black

markings, as well as by the deeper yellow colour of the abdomen, and by the yellow thighs, the latter being, in *M. fülleborni* brownish, tinged with yellow. The flanks were also paler, being browner and of a clearer chestnut shade in *M. fülleborni*.

6. Macronyx aurantiigula.

Mocronyx aurantiigula, Reichen., *Journ. f. Ornith.*, 1891, p. 222: Shelley, "B. Africa," vol. 3, p. 10 (1902): Reichen., "Vög. Afrikas," vol. 3, p. 324 (1904).

Hab. East Africa. Pangani River (Reichen., *Journ. f. Ornith.*, 1891, p. 222: *id.*, *Journ. f. Ornith.*, 1892, p. 52: *id.*, "Vög. Deutsch. Ost. Afrikas," p. 199, 1894). Manjara Lake (Neumann, *Journ. f. Ornith.*, 1900, p. 290). Maurui, Jan.; Maeru Mts.; Mt. Kiliminjaro (Fischer, *Zeitschr. ges. Orn.*, vol. 1, p. 308, 1884). Mt. Doinyo Narok, 4,300 feet, March, 1906 (*Percival:* Mus. F. J. Jackson).

7. Macronyx sharpei.

Macronyx sharpei, Jackson, *Bull. B.O.C.*, vol. 14, p. 74 (1904): *id.*, *Ibis*, 1905, p. 102, pl. 3: Reichen., "Vög. Afrikas," vol. 3, p. 323 (1904).

Hab. Equatorial Africa. Higher portions of the great Mau Plateau, between 7,000 and 8,500 feet elevation. Near the railway station of Lundiani at the head of the Nyando Valley (7,500 feet). Breeds. (Jackson, *Ibis*, 1905, p. 102); Loliondo River, Likipia (7,000 feet), July 1, 1906 (Mus. F. J. Jackson).

8. Macronyx ameliae.

Macronyx ameliæ (Tarr.), Sharpe, "Cat. B. Brit. Mus.," vol. 10, p. 628 (1885): Shelley, "B. Africa," vol. 3, p. 12 (1902): Reichen., "Vög. Afrikas," vol. 3, p. 324 (1904).

Hab. Natal (*R. S. Fellows:* Sharpe Coll.: Brit. Mus.). Umlaas Flats, Dec. (*Gordge:* Shelley Coll.). Zulu Land.

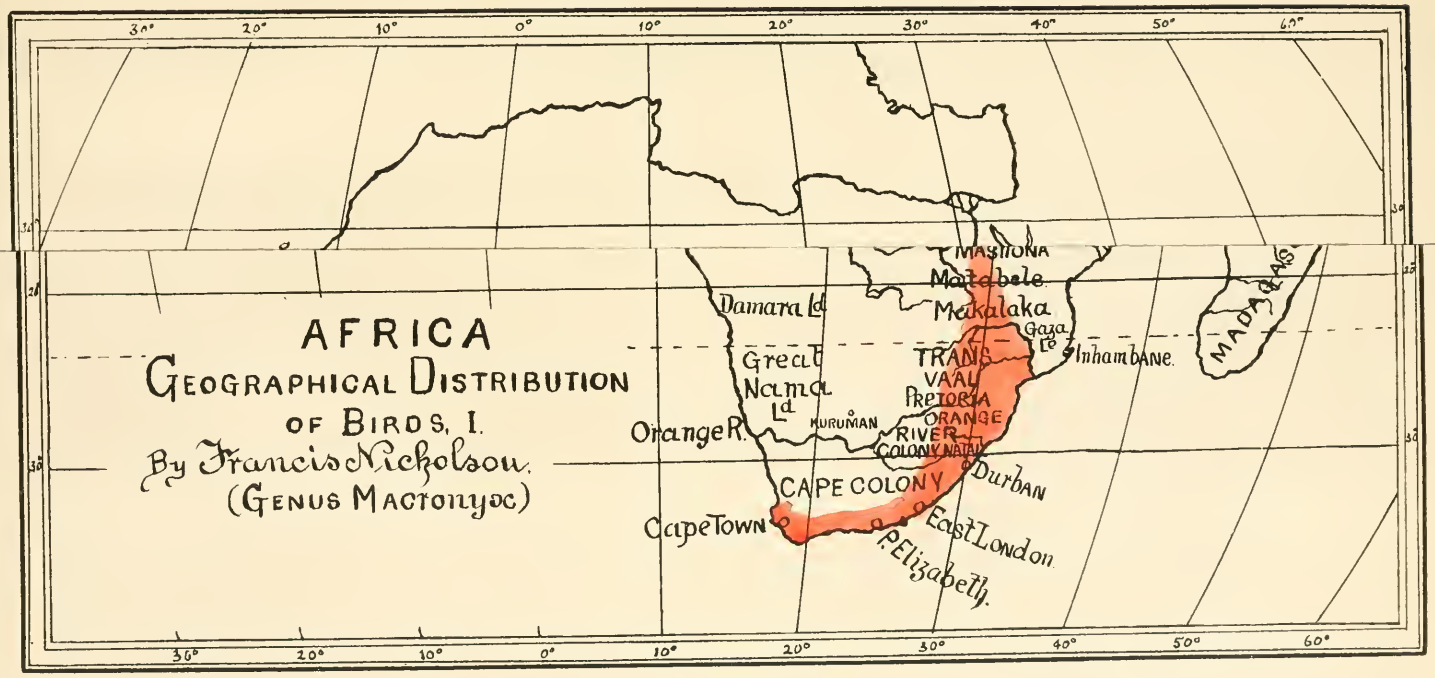
Umfolosi Station, Zulu Land, June-Aug. (*Claude Grant*, Mus. Brit.). Santa Lucia Lake (Woodward, *Ibis*, 1900, p. 524). Matabele Land. Pantamatenka R. (*Bradshaw*: Shelley "B. Africa," vol. 3, p. 12). Zambesia; Chicowa, Zambesi R. (Boyd Alexander, *Ibis*, 1899, p. 563 *(s.n. M. wintoni)*).

9. **Macronyx wintoni.**

Macronyx wintoni, Sharpe, *Ibis*, 1891, pp. 444, 589: Jackson, *Ibis*, 1899, p. 630: Reichen., "Vög. Afrikas," vol. 3, p. 325 (1904). *Macronyx ameliae*, Shelley, "B. Africa," vol. 3, p. 12 (1902).

Hab. Equatorial Africa. Found in three places only—in the Rift Valley in the vicinity of Lake Naivasha, the eastern side of the Guashangishu plateau, and in the Nyando Valley in the vicinity of Kitotos (Jackson, *Ibis*, 1905, p. 103). West shores of Manjara Lake, Nov. 28, 1893: Mgogo, N. of Manjara Lake, Dec. 6, 1893. Kossowa, March 3, 1894, Kavirondo, Oct.: Kwa Kissero, Mori Bay, Nguruman (*Neumann*: Reichen., "Vög. Afrikas," vol. 3, p. 325, 1904).

Macronyx wintoni is a small race of *M. ameliae*, and, according to Dr. Bowdler Sharpe, differs from the latter in its lesser size and smaller bill. Shelley unites it to *M. ameliae*, but I think the constantly smaller size is a sufficiently good character for its separation.

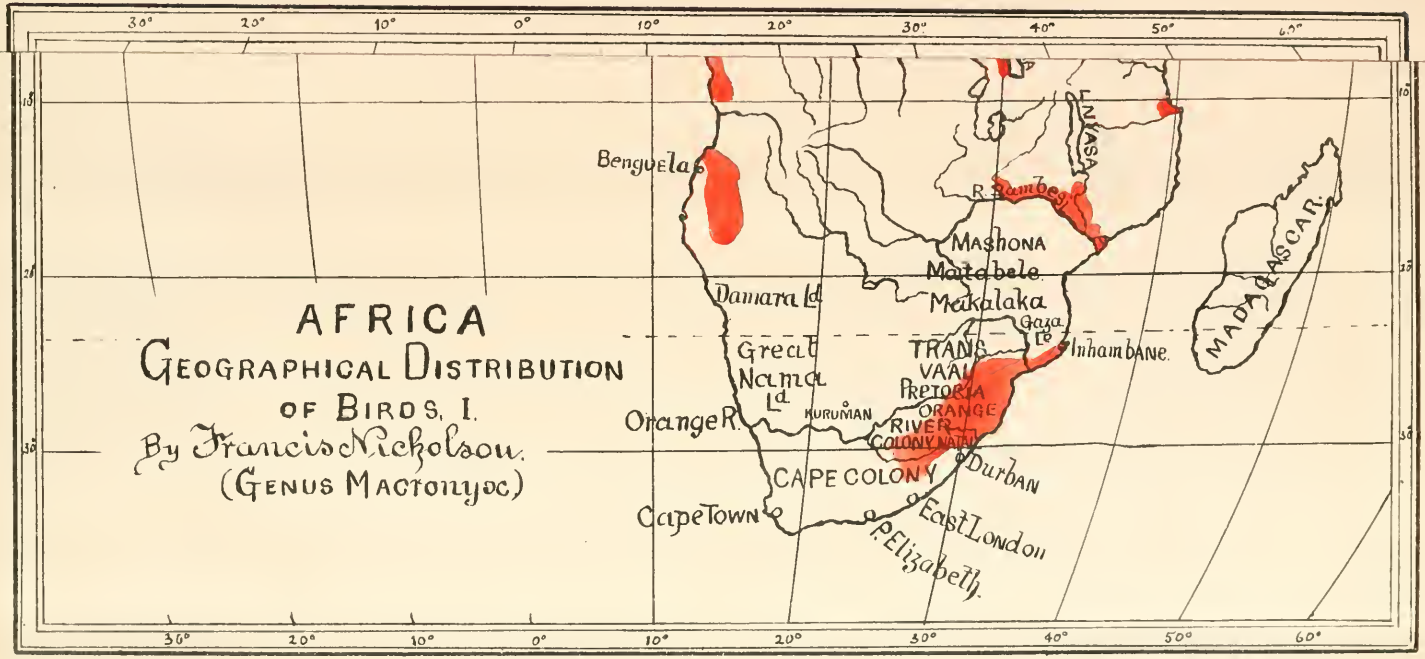


Red. *Macronyx capensis.* Green. *M. flavicollis.* Blue. *M. fülleborni.*

Yellow. *M. ascensi.* Purple. *M. sharpei.*

Red. *Macronyx capensis.* Green. *M. flavicollis.* Blue. *M. fuelleborni.*

Yellow. *M. ascensi.* Purple. *M. sharpei.*



Red. *M. croceus.*

Red. *M. croceus*

Red. *M. aurantiigula.* Green. *M. ameliae.* Blue. *M. wintoni.*

Red. *M. aurantiigula.* Green. *M. ameliae.* Blue. *M. wintoni.*

Mr. R. L. TAYLOR, F.C.S., F.I.C., read a paper entitled, **"On some Colour Demonstrations of the Dissociating Action of Water."**

Mr. HENRY SIDEBOTTOM read a paper entitled **"Report on the Recent Foraminifera from the Coast of the Island of Delos (Grecian Archipelago). Part VI." (Conclusion.)**

Examples of *Polytrema miniaceum*, Linné sp., *Truncatulina variabilis*, d'Orbigny, and a decorated form of *Rotalia beccarrii*, Linné, were shown under the microscope, and drawings of numerous other species were exhibited.

Mr. GEORGE HICKLING, B.Sc., read a paper entitled, **"On Permian Foot-prints."**

The three papers will be printed in the *Memoirs*.

Annual General Meeting, April 20th, 1909.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

The Annual Report of the Council and the Statement of Accounts were presented, and it was resolved:—"That the Annual Report, together with the Statement of Accounts, be adopted, and that they be printed in the Society's *Proceedings*."

The Secretary announced, in accordance with Rule 22 of the Articles of Association, that the name of E. F. Morris had been erased by the Council from the register in consequence of the non-payment of his subscription.

Mr. H. BATEMAN and Mr. R. H. CLAYTON were appointed Scrutineers of the balloting papers.

The following members were elected officers of the Society and members of the Council for the ensuing year.

President: FRANCIS JONES, M.Sc., F.R.S.E.

Vice-Presidents: H. B. DIXON, M.A., F.R.S.; THOMAS

THORP, F.R.A.S.; ERNEST RUTHERFORD, F.R.S.; F. W. GAMBLE, D.Sc., F.R.S.

Secretaries: R. L. TAYLOR, F.C.S., F.I.C.; C. GORDON HEWITT, M.Sc.

Treasurer: ARTHUR McDOUGALL, B.Sc.

Librarian: C. L. BARNES, M.A.

Other Members of the Council: FRANCIS NICHOLSON, F.Z.S.; ERNEST F. LANGE, F.C.S., M.I.Mech.E.; HORACE LAMB, M.A., LL.D., D.Sc., Sc.D., F.R.S.; W. H. TODD; ARTHUR SCHUSTER, Sc.D., Ph.D., F.R.S.; EDMUND KNECHT, Ph.D.

Ordinary Meeting, April 20th, 1909.

Professor H. B. DIXON, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Mr. W. S. ASCOLI, F.R.G.S., read a paper, communicated by Mr. C. E. STROMEYER, M.Inst.C.E., entitled "**The Guatemalan Earthquakes and Eruption of 1902.**" The lecture is published in a condensed form in the *Memoirs*.

At this point the chair was occupied by Mr. FRANCIS JONES, M.Sc., F.R.S.E.

Mr. F. H. GRAVELY, M.Sc., read a paper entitled "**Apical Pigment-Spots in the Pluteus of *Echinus miliaris*,**" of which the following is an abstract.

In advanced living plutei of *Echinus miliaris* from the plankton of Port Erin Bay, there are present in close association with the apical plate two pairs of pigment-spots, and one pair of tufts of stiff cilia. The anterior pair of pigment-spots are small and of a transparent red colour. The posterior pair are larger, and of an opaque yellow. They are situated in the

general cavity, closely applied to the inner surface of the apical plate, and are probably composed of the same substance as are similar cells described by MacBride in other parts of the body —especially in large masses beneath the four epaulettes—of the pluteus of *Echinus esculentus*. This substance occurs, with a similar distribution, in the pluteus of *E. miliaris*. Whether the definitely paired spots of this and the red pigment in association with the apical plate of *E. miliaris*, or the tufts of stiff cilia also found in this position, have any sensory function, as might *à priori* be expected from their position, has not been determined.

Ordinary Meeting, May 4th, 1909.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables. The following were among the recent accessions to the Society's Library: "*Flora Capensis*,"...vol. 4 sect. 1, part 6, by Sir W. T. Thiselton-Dyer (8vo, London, 1909), purchased; "*Third Report on Research Work...on the Storage of Raw River Water antecedent to Filtration*," by Dr. A. C. Houston (fol., London, 1909), presented by the Metropolitan Water Board; "*The Battle of Gettysburg*," by F. A. Haskell (8vo., n. pl., 1908), presented by the Wisconsin History Commission; "*Atlas of the World with Index*," by G. W. Bacon (fol., London, 1908), and "*International Dictionary of the English Language*," by W. Webster (fol., London, 1907), purchased.

Mr. R. L. TAYLOR, F.I.C., exhibited a drawing of John Dalton, signed by J. Stephenson, and dated June, 1882, which had been for many years in the possession of Messrs. Steinthal. It was thought that this was the original from which the celebrated engraving by that artist was made.

Professor E. KNECHT, Ph.D., read a paper, written in conjunction with Mr. J. P. BATEY, M.Sc.Tech., entitled, "**A Modification of the Beckmann Apparatus by which Constant Readings are obtained in determining the Boiling Points of Aqueous Solutions.**"

Miss MARIE C. STOPES, Ph.D., D.Sc., and Mr. C. GORDON HEWITT, M.Sc., read a joint paper, entitled, "**On the Tent-building Habits of the Ant,** *Lasius Niger*, **Linn., in Japan.**"

Professor H. F. RUGAN, of Tulane University, U.S.A., read a paper, written in conjunction with Professor H. C. H. CARPENTER, Ph.D., of Manchester University, entitled, "**The Permanent Change of Volume of Cast Irons after repeated Heatings.**"

Samples of Iron that had been subjected to repeated heatings were exhibited, and showed very clearly how considerable was the growth that had taken place.

The first two of these three papers are printed in the *Memoirs*.

Annual Report of the Council, April, 1909.

The Society began the session with an ordinary membership of 156. During the present session 16 new members have joined the Society. Ten resignations have been received, and there has been one death, *viz.:* Mr. Standen Paine. This leaves on the roll 161 ordinary members. The Society has also lost, by death, 2 honorary members, *viz.:* Professor Gustave Dewalque, of Liège, and Professor E. E. N. Mascart, of Paris, For.Mem.R.S. Memorial notices of these gentlemen appear at the end of this report.

The average attendance at the meetings was 30 as compared with 32 for the session 1907-08.

The Society commenced the session with a balance in hand of £208. 19s. 6d., from all sources, this amount being made up of the following balances :—

At the credit of General Fund.....	£17	0	9
,, ,, Wilde Endowment Fund...	66	18	1
,, ,, Joule Memorial Fund.....	88	1	0
,, ,, Dalton Tomb Fund	36	19	8
	£208	19	6

The total balance in hand at the close of the session amounted to £278. 1s. 6d., and the amounts standing at the credit of the separate accounts, on the 31st March, 1909, are the following :—

At the credit of General Fund.....	£46	10	10
,, ,, Wilde Endowment Fund...	114	2	2
,, ,, Joule Memorial Fund	79	10	10
,, ,, Dalton Tomb Fund	37	17	8
Balance 31st March, 1909.....	£278	1	6

The Wilde Endowment Fund, which is kept as a separate banking account, shows a balance of £114. 2s. 2d. in its favour, as against £66. 18s. 1d., at the beginning of the financial year, there being an increase of ten pounds in the receipts from the invested funds as compared with the receipts for several years past.

The Joule Memorial Fund has this year incurred an expenditure of sixteen pounds five shillings by the purchase and repair of a silver chronometer watch, formerly belonging to the late Dr. J. P. Joule, which the Council has resolved to place in one of the Society's rooms as a memorial of a distinguished past President.

The Librarian reports that during the session 876 volumes have been stamped, catalogued and pressmarked, 759 of these being serials, and 117 separate works. There have been written 366 catalogue cards, 211 for serials, and 155 for separate works. The total number of volumes catalogued to date is 31,549 for which 11,225 cards have been written.

Satisfactory use is made of the library for reference purposes, but the number of volumes consulted is not recorded. During the session, 175 volumes have been borrowed from the library, as compared with 200 in the previous session.

Further attention has been given to the completion of sets, 68 volumes or parts having been obtained, which complete three sets, and partly complete four. Of these, 8 volumes were purchased, 20 volumes were presented by Mr. Francis Nicholson, and the rest were presented by the societies publishing them.

A larger amount of binding than usual has been done this session, 316 volumes having been bound in 228.

A record of the accessions to the library shows that, from April, 1908, to March, 1909, 737 serials and 113 separate works

were received, a total of 850 volumes. The donations during the session (exclusive of the usual exchanges) amount to 129 volumes and 177 dissertations; one volume has been purchased (in addition to the periodicals on the regular subscription list).

During the past session the Society has arranged to exchange publications with the following:—Società Italiana per il Progresso delle Scienze, Rome; Manchester Municipal School of Technology; Observatorio Meteorologico Mérida de Yucatan; the *Philippine Journal of Science*, Manila; Sociedad de Ingenieros del Peru, Lima; and the Servicio Meteorológico de la República Boliviana, La Paz.

The publication of the *Memoirs and Proceedings* has been continued under the supervision of the Editorial Committee.

The Society is indebted to the following for the undermentioned gifts:—

Dr. Henry Wilde, F.R.S., for six volumes of *Hope Reports*, published by the Hope Department of Zoology in the University of Oxford.

Professor A. Schuster, F.R.S., for two volumes of the *Comptes Rendus des Séances...de la Commission Permanente de l'Association Internationale de Sismologie.*

Mr. Francis Nicholson, F.Z.S., for the following works:—*Nicholson's Journal*, vols. 1—5, 1798—1801; *Annalen der Physik*, Neueste Folge, Bde. 1—12, 1819—1822; "Studies in Anatomy from the Anatomical Department of the Owens College," vols. 1, 2, 1891, 1900; "Studies from the Physiological Laboratory of Owens College. Manchester," vol 1, 1891; "Handbook of the Manchester Meeting of the British Association," 1887, and "Excursions of the British Association, Manchester," 1887.

Gesellschaft Naturforschender Freunde, Berlin, for *Archiv für Biontologie*, vols. 1—3.

Dr. H. Brereton Baker, F.R.S., Lee's Reader in Chemistry in the University of Oxford, was invited to deliver the Wilde Lecture for 1909. The Lecture, on "The Influence of Moisture on Chemical Change," was delivered on Tuesday, March 9th, 1909.

The Linnean Society of London celebrated on July 1st, 1908, the fiftieth anniversary of the reading of the joint essay by Charles Darwin and A. R. Wallace, entitled "On the Tendency of Species to form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection," and this Society was represented by Mr. Charles Bailey, M.Sc., F.L.S.

The University Museum of Oxford celebrated its Jubilee on October 8th, 1908, and this Society was represented by the President, Professor H. B. Dixon, M.A., F.R.S., who presented the following address which had been approved by the Members:—

To the Vice-Chancellor of the University of Oxford.

"We, the Council of the Manchester Literary and "Philosophical Society, desire to offer to the University of "Oxford our greetings and congratulations on the celebration "of the Jubilee of the University Museum.

"Meeting, as our Council does, in the workroom of John "Dalton, we think it not unfitting to recall that the concep- "tion of the chemical elements on which Dalton founded "his Atomic Theory, originated with Robert Boyle, at "Oxford; and that the recognition by chemists of the "diatomic molecules of Avogadro (which reconciled the "conflicting views of Dalton and of Gay-Lussac) was largely "due to the work carried out by Brodie in the Chemical "Laboratory of the Oxford Museum.

"We have watched with the keenest interest the extensions "of the Oxford Museum, and the widening scope of its "activities and usefulness; we are glad to recognise that "this increase accompanies and symbolises the growth in

"Oxford of a new sympathy for scientific study and research,
"which now take their place, honoured and giving honour,
"side by side with the older learning."

Signed, on behalf of the Manchester Literary and Philosophical Society.

H. B. DIXON, *President.*

F. W. GAMBLE, } *Hon. Secs.*
R. L. TAYLOR, }

September 29th, 1908.

It was resolved that Dr. F. W. Gamble, F.R.S., one of the Hon. Secretaries, be asked to represent this Society on the occasion of the Darwin Centenary Celebrations at Cambridge, in June, 1909.

The Geological Society of Glasgow celebrated its Jubilee on January 28th, 1909, and this Society was represented by Mr. D. M. S. Watson, B.Sc.

Gilles Joseph Gustave Dewalque was elected an honorary member of this Society on the 17th of April, 1888. Born at Stavelot, in Belgium, on the 2nd of December, 1826, he became one of his country's most famous geologists, maintaining an active leadership in scientific enquiry almost to the day of his death at the ripe age of seventy-eight, on the 3rd of November, 1905.

His brilliant work was rewarded with many honours. At the University of Liége he received the Doctorates of Medicine and Science, and in 1857 followed his famous predecessor, Dumont, in the chair of Geology there. Eight years later the subjects of Mineralogy and Palæontology were also committed to his care. His great interest in British Geology led to his election, in 1871, as a Foreign Correspondent of the Geological Society of London, and in 1880 as a foreign member. He was

himself one of the founders of the active Société Géologique de Belgique. In addition to membership of many other Scientific Societies in Belgium, Moscow, Vienna, Luxembourg, etc., he received many civil honours, notably the Commandeur de l'Ordre de Leopold, and Officier de l'Ordre des Sts Maurice et Lazare.

His earlier researches were on the Liassic rocks of Luxembourg, on which he published, in 1853, in collaboration with F. Chapius, an important monograph, "Description des Fossiles des Terrains Secondaires de la Province de Luxembourg." His later researches led him over the whole range of stratified rocks in Belgium, from the Cambrian to the most recent, but his contributions to our knowledge of the very important Devonian rocks of that country stand out prominently. He did much towards unravelling the complicated tectonic geology of his own country, and was an ardent worker on the correlation of the stratigraphical series in England and Belgium. The latter problem was the cause of his being a frequent contributor to the *Quarterly Journal of the Geological Society* and the *Geological Magazine*. Among his other works, his "Prodrome d'une Description Géologique de Belgique," published in 1868, and revised in 1880, is notable, together with his "Carte géologique de la Belgique et des Provinces voisines, 1899." It is a tribute to his lasting energy that he presented to the Geological Society a new map of Belgium, only a few months before his greatly lamented death. G. H.

Éleuthère Élie Nicolas Mascart was born at Quarouble, near Valenciennes, on February 20th, 1837. Having completed his studies at the École normale supérieure of Paris, he was admitted to the degree of Docteur-es-Sciences in the year 1864, and soon afterwards received an appointment at the "Lycée" of Versailles as Professor of Physics. In the year 1872 he succeeded Regnault at the collège de France, where he filled the chair of Physics until he took charge of the Central Bureau of Meteorology in 1878.

Mascart was probably the first physicist who recognised the services which photography could render to the progress of science. At an early period of his career, and in the early stages of Spectrum Analysis, Mascart contributed to its advance by the construction of photographic charts and accurate measurements of wave-length. Among his other contributions to science, his researches on the refraction and dispersion of gases deserve special mention.

We also owe to Mascart systematic treatises on Electricity, Optics, and Terrestrial Magnetism; these are all distinguished by critical insight and clear exposition of facts.

His pre-eminence as an organiser found ample scope in the reorganisation of the meteorological service of France. When he appeared—as he often did—at international assemblies of scientific men, he made his presence felt by his charming personality no less than by his experience in the conduct of business.

He was elected a member of the French Academy of Sciences in 1884, and Foreign Member of the Royal Society in 1892. He retired from his official duties in 1907, and died on August 26th, 1908. A. S.

Mr. Standen Paine, Pharmaceutical Chemist, died at his residence, Devisdale, Bowdon, on October 4th, 1908, at the age of 73.

Mr. Paine, who served his apprenticeship with the historic house of John Bell & Co., Oxford Street, London, came to Manchester 45 years ago with the late Mr. Frederick Baden Benger to manage the business of Mottershead & Co. in the Market Place, and they became joint partners in the business a few years later. The success of Benger's food, of which Mr. Benger was the originator, is well known, and Mr. Paine, as senior partner, was the head of this firm, also taking an active part in its management until a few days before his death.

He joined the Society in 1901, but has not taken an active part in its affairs. A. B.

MANCHESTER LITERARY AN

Dr. *Arthur McDougall, Treasurer, in Account with*

			£ s. d.	£ s
To Cash in hand, 1st April, 1908				105 1
To Members' Subscriptions :—				
Half Subscriptions, 1907-08,	3 at £1 1s. 0d.		3 3 0	
,, ,, 1908-09,	21 ,, ,,		22 1 0	
Subscriptions :— 1906-07,	2 ,, £2. 2s. 0d.		4 4 0	
,, 1907-08,	9 ,, ,,		18 18 0	
,, 1908-09,	114 ,, ,,		230 8 0	
,, 1909-10,	1 ,, ,,		2 2 0	
				289 16
To Transfers from the Wilde Endowment Fund			.. ..	79 8
To Sale of Publications			.. ..	10 9
To Dividends :—				
Natural History Fund			58 3 9	
Joule Memorial Fund			7 7 2	
				65 10
To Income Tax Refunded :—				
Natural History Fund			3 1 3	
Joule Memorial Fund			0 7 8	
Wilde Endowment Fund			16 15 0	
				20 3
To H. Sidebottom for plates			.. ..	8 0
To Discount on Subscription for 'Chemical Abstracts,' 1908			.. ..	0 3
To Compensation from Employers' Liability Assurance Corporation Ltd.			.. ..	4 2
				£582 16

NATURAL HISTOR

	£ s.
To Dividends on £1,225 Great Western Railway Company's Stock	58 3
To Remission of Income Tax, 1908	3 1
	£61 5

JOULE MEMORIA

	£ s.
To Balance, 1st April, 1908	88 1
To Dividends on £258 Loan to Manchester Corporation	7 7
To Remission of Income Tax, 1908	0 7
	£95 15

WILDE ENDOWMEN

	£ s.
To Balance 1st April, 1908	66 18
To Dividends on £7,500 Gas Light and Coke Company's Ordinary Stock	323 0
To Remission of Income Tax, 1908	16 15
To Bank Interest	1 0
	£407 13

DALTON TOM

	£ s.
To Balance 1st April, 1908	36 19
To Bank Interest	0 18
	£37 17

HILOSOPHICAL SOCIETY.

ciety, from 1st April, 1908, to 31st March, 1909. Cr.

	£ s. d.	£ s. d.
Charges on Property :—		
Chief Rent (Income Tax deducted)	12 5 4	
Income Tax on Chief Rent	0 12 11	
Insurance against Fire	13 17 6	
House Expenditure :—		26 15 9
Coals, Gas, Electric Light, Water, &c.	40 0 0	
Tea, Coffee, &c., at Meetings	17 4 1	
Cleaning, Sweeping Chimneys, &c.	7 7 5½	
Replacements of mantles, crockery, towels, table cloths, dusters, etc.	2 0 8	
Administrative Charges :—		66 12 2½
Housekeeper	65 0 0	
Postages, and Carriage of Parcels and of "Memoirs"	31 4 7½	
Stationery, Cheques, Receipts, and Engrossing	6 3 11	
Members' Declaration Book	2 5 0	
Printing Circulars, Reports, &c.	11 11 0	
Extra attendance at Meetings, and during housekeeper's holidays	3 8 0	
Insurance against Liability	0 12 0	
Extra assistance for Mrs. Kelly	1 13 0	
Medical advice and attendance for Mrs. Kelly	2 13 6	
Miscellaneous Expenses	1 9 1	
		126 0 1½
Publishing :—		
Printing "Memoirs and Proceedings"	109 15 6	
Illustrations for "Memoirs" (except Nat. Hist. papers)	11 10 6	
Binding "Memoirs"	2 0 0	
Library :—		123 6 0
Books and Periodicals (except those charged to Natural History Fund)	22 12 5	
Periodicals formerly subscribed for by the Microscopical and Natural History Section	4 15 8	
		27 8 1
Natural History Fund :—		
(Items shown in the Balance Sheet of this Fund below)		53 12 9
Joule Memorial Fund :—		
(Items shown in the Balance Sheet of this Fund below)		16 5 0
Wilde Endowment Fund (Income Tax refunded)		16 15 0
Balance at Williams Deacon's Bank, 1st April, 1909	116 1 8	
,, in Treasurer's hands	10 0 0	
		126 1 8
		£582 16 7

UND, 1908—1909. (Included in the General Account, above.)

	£ s. d.
Natural History Books and Periodicals	46 4 9
illustrations for papers on Nat. Hist. in "Memoirs"	7 8 0
Balance, 1st April, 1909	7 12 3
	£61 5 0

UND, 1908—1909. (Included in the General Account, above.)

	£ s. d.
Purchase of Chronometer belonging to Dr. J. P. Joule	15 15 0
Repairing ,, ,,	0 10 0
Balance, 1st April, 1909	79 10 10
	£95 15 10

UND, 1908—1909.

	£ s. d.
Assistant Secretary's Salary, April, 1908, to March, 1909	150 0 0
Maintenance of Society's Library :—	
Binding and Repairing Books	38 9 7
Repairs and Improvements to Society's Premises	7 4 0
Re-caning Chairs	2 12 6
Honorarium to Wilde Lecturer, 1909	15 15 0
Transfers to Society's Funds	79 8 0
Cheque Book	0 2 6
Balance at District Bank, 1st April, 1909	114 2 2
	£407 13 9

UND, 1908—1909.

	£ s. d.
No Expenditure this Session).	
Balance at Manchester and Salford Savings Bank, 1st April, 1909	37 17 8
	£37 17 8

NOTE.—The Treasurer's Accounts of the Session 1908-1909, of which the foregoing pages are summaries, have been endorsed as follows:

April 7th, 1909. Audited and found correct.

We have also seen, at this date, the certificates of the following Stocks held in the name of the Society:—£1,225 Great Western Railway Company 5% Consolidated Preference Stock, Nos. 12,293, 12,294, and 12,323; £258 Twenty years' loan to the Manchester Corporation, redeemable 25th March, 1914 (No. 1,564); £7,500 Gas Light and Coke Company Ordinary Stock (No. 6,389); and the deeds of the Natural History Fund, of the Wilde Endowment Fund, those conveying the land on which the Society's premises stand, and the Declaration of Trust.

Leases and Conveyance dated as follow:—

22nd Sept., 1797.
23rd Sept., 1797.
25th Dec., 1799.
,, ,, ,,
22nd Dec., 1820.
23rd Dec., 1820.

Declarations of Trust:—

8th Jan., 1878.
24th June, 1801.
23rd Dec., 1820.
30th April, 1851.

We have also verified the balances of the various accounts with the bankers' pass books.

(Signed) W. HENRY TODD.
C. GORDON HEWITT.

THE COUNCIL

AND MEMBERS

OF THE

MANCHESTER

LITERARY AND PHILOSOPHICAL SOCIETY.

(Corrected to July 4th, 1909.)

President.

FRANCIS JONES, M.Sc., F.R.S.E., F.C.S.

Vice-Presidents.

H. B. DIXON, M.A., F.R.S., F.C.S.
THOMAS THORP, F.R.A.S.
ERNEST RUTHERFORD, D.Sc., F.R.S.
F. W. GAMBLE, D.Sc., F.R.S.

Secretaries.

R. L. TAYLOR, F.C.S., F.I.C.
C. GORDON HEWITT, M.Sc.

Treasurer.

ARTHUR McDOUGALL, B.Sc.

Librarian.

C. L. BARNES, M.A.

Other Members of the Council.

FRANCIS NICHOLSON, F.Z.S.
ERNEST F. LANGE, F.C.S.
HORACE LAMB, M.A., LL.D., D.Sc., F.R.S.
ARTHUR SCHUSTER, Sc.D., Ph.D., F.R.S.
W. H. TODD.
EDMUND KNECHT, Ph.D.

Assistant Secretary and Librarian.

A. P. HUNT, B.A.

ORDINARY MEMBERS.

Date of Election.

1901, Dec. 10. Adamson, Harold. *Oaklands Cottage, Gotley, near Manchester.*

1902, Mar. 18. Allen, J. Fenwick. 147, *Withington Road, Whalley Range, Manchester.*

1870, Dec. 13. Angell, John, F.C.S., F.I.C. 6, *Beaconsfield, Derby Road, Withington, Manchester.*

1865, Nov. 14. Bailey, Charles, M.Sc., F.L.S. *Haymesgarth, Cleeve Hill S.O., Gloucestershire.*

1888, Feb. 7. Bailey, Alderman Sir William H., M.I.Mech.E. *Sale Hall, Sale, Cheshire.*

1895, Jan. 8. Barnes, Charles L., M.A. 9, *York Place, Chorlton-on-Medlock, Manchester.*

1903, Oct. 20. Barnes, Jonathan, F.G.S. *South Cliff House*, 301, *Great Clowes Street, Higher Broughton, Manchester.*

1908, Feb. 11. Bateman, H., M.A., Reader in Mathematical Physics in the University of Manchester. *The University, Manchester.*

1895, Mar. 5. Behrens, Gustav. *Holly Royde, Withington, Manchester.*

1898, Nov 29. Behrens, Walter L. 22, *Oxford Street, Manchester.*

1868, Dec. 15. Bickham, Spencer H., F.L.S. *Underdown, Ledbury.*

1901, Nov. 12. Bles, Abraham J. S. *Palm House, Higher Broughton, Manchester.*

1896, Oct. 6. Bowman, F.H., D.Sc., F.R.S.E. 4, *Albert Square, Manchester.*

1875, Nov. 16. Boyd, John. *Barton House*, 11, *Didsbury Park, Didsbury, Manchester.*

1889, Oct. 15. Bradley, Nathaniel, F.C.S. *Sunnyside, Whalley Range, Manchester.*

1861, April 2. Brogden, Henry, F.G.S., M.I.Mech.E. *Hale Lodge, Altrincham, Cheshire.*

1889, April 16. Brooks, Samuel Herbert. *Slade House, Levenshulme, Manchester.*

1860, Jan. 24. Brothers, Alfred. *Handforth, near Manchester.*

1886, April 6. Brown, Alfred, M.A., M.D. *Sunlycroft, Higher Broughton, Manchester.*

1889, Jan. 8. Brownell, Thomas William, F.R.A.S. 64, *Upper Brook Street, Manchester.*

1889, Oct. 15. Budenberg, C. F., M.Sc., M.I.Mech.E. *Boxdon Lane, Marple, Cheshire.*

Date of Election.

1906, Feb. 27. Burton, Joseph, A.R.C.S. Dublin. *Tile Works, Clifton Junction, near Manchester.*

1894, Nov. 13. Burton, William, M.Sc., F.C.S. *The Hollies, Clifton Junction, near Manchester.*

1904, Oct. 18. Campion, George Goring, L.D.S. 264, *Oxford Street, Manchester.*

1907, Jan. 15. Carpenter, H. C. H., M.A., Ph.D., Professor of Metallurgy in the University of Manchester. 11, *Oak Road, Withington, Manchester.*

1899, Feb. 7. Chapman, D. L., M.A., Fellow of Jesus College, Oxford. *Jesus College, Oxford.*

1901, Nov. 26. Chevalier, Reginald C., M.A., Mathematical Master at the Manchester Grammar School. 103, *Clyde Road, West Didsbury, Manchester.*

1907, Nov. 26. Clayton, Robert Henry, B.Sc., Chemist. *Woodleigh, Blackfield Lane, Kersal, Manchester.*

1901, Nov. 12. Coignou, Caroline, M.A., Science Mistress at the Manchester High School for Girls. 60, *Cecil Street, Greenheys, Manchester.*

1895, April 30. Collett, Edward Pyemont. 8, *St. John Street, Manchester.*

1903, Oct. 20. Core, William Hamilton, M.Sc. *Groombridge House, Withington, Manchester.*

1906, Oct. 30. Coward, H. F., M.Sc., Assistant Lecturer in Chemistry in the University of Manchester. *Hulme Hall, Plymouth Grove, Manchester.*

1906, Nov. 27. Coward, Thomas Alfred, F.Z.S. *Brentwood, Bowdon, Cheshire.*

1908, Nov. 3. Cramp, William, M.Sc.Tech., M.I.E.E., Consulting Engineer. 20, *Mount Street, Manchester.*

1895, Nov. 12. Crossley, W. J., M.I.Mech.E. *Openshaw, Manchester.*

1901, Nov. 26. Darbishire, Francis V., B.A., Ph.D., Demonstrator and Analyst at the South Eastern Agricultural College. *The College, Wye, Kent.*

1895, April 9. Dawkins, W. Boyd, M.A., D.Sc., F.R.S., Honorary Professor of Geology in the Victoria University of Manchester. *Fallowfield House, Fallowfield, Manchester.*

1894, Mar. 6. Delépine, A. Sheridan, M.B., B.Sc., Professor of Pathology in the Victoria University of Manchester. *The University, Manchester.*

Date of Election.

1887, Feb. 8. Dixon, Harold Baily, M.A., M.Sc., F.R.S., F.C.S., Professor of Chemistry in the Victoria University of Manchester. *The University, Manchester.*

1906, Jan. 30. Dunkerley, Stanley, D.Sc.

1906, Oct. 30. Edgar, E. C., D.Sc., Assistant Lecturer and Demonstrator in Chemistry in the University of Manchester. *The University, Manchester.*

1902, May 13. Ellison, Robert William. *'Brookside,' Crofts Bank Road, Urmston, Manchester.*

1906, Nov. 13. Fisher, Kenneth, B.A. Oxon., Ph.D. Jena, Research Student in the University of Manchester. *The Lilacs, Timperley, Cheshire.*

1907, Nov. 26. Flatters, Abraham, F.R.M.S. *Sydial Cottage, Bramhall, Cheshire.*

1908, Mar. 10. Fowler, W. H., M.Inst.C.E. *Sale Lodge, Sale, Cheshire.*

1908, Jan. 28. Fox, Thomas William, M.Sc.Tech., Professor of Textiles in the School of Technology, Manchester University. 15, *Clarendon Crescent, Eccles.*

1898, Nov. 29. Gamble, F. W., D.Sc., F.R.S., Assistant Director of the Zoological Laboratories in the Victoria University of Manchester. *The University, Manchester*, and *Heathwaite, Bramhall Lane, Stockport.*

1909, Mar. 23. Gee, W. W. Haldane, B.Sc., M.Sc.Tech., A.M.I.E.E., Professor of Pure and Applied Physics in the School of Technology, Manchester University. *Oak Lea, Whalley Avenue, Sale.*

1908, Oct. 6. Gibson, A. H., M.Sc., Assoc.M.Inst.C.E., Demonstrator and Assistant Lecturer in Engineering in the University of Manchester. *The University, Manchester.*

1896, Nov. 17. Gordon, Rev. Alexander, M.A. *Summerville, Victoria Park, Manchester.*

1907, Oct. 15. Gravely, F. H., M.Sc., Assistant Lecturer and Demonstrator in Zoology in the University of Manchester. *Dalton Hall, Victoria Park, Manchester.*

1907, Oct. 29. Gwyther, Reginald Felix, M.A., Secretary to the Joint Matriculation Board. 21, *Booth Avenue, Withington, Manchester.*

Date of Election.

1902, April 29. Herbert, Arthur M., B.A. *Frankwyn, Hale, Cheshire.*

1905, Oct. 17. Hewitt, Charles Gordon, M.Sc., Lecturer in Economic Zoology in the Victoria University of Manchester. *The University, Manchester.*

1902, Jan. 7. Hewitt, David B., M.D. *Grove Mount, Davenham, Cheshire.*

1907, Oct. 15. Hickling, H. George A., B.Sc., Assistant Lecturer and Demonstrator in Geology in the University of Manchester. 50, *Lancaster Road, Fallowfield, Manchester.*

1895, Mar. 5. Hickson, Sydney J., M.A., D.Sc., F.R.S., Professor of Zoology in the Victoria University of Manchester. *The University, Manchester.*

1884, Jan. 8. Hodgkinson, Alexander, M.B., B.Sc. 18, *St. John Street, Manchester.*

1909, Jan. 12. Hoffert, Hermann Henry, D.Sc. (Lond.), A.R.S.M., His Majesty's Inspector of Schools. *Lime Grove, Brooklands, Sale.*

1906, Oct. 16. Holmes, H. T., M.A. (Cantab.). *Eastnor*, 77, *Wellington Road, Heaton Chapel.*

1905, Nov. 14. Holt, Alfred, M.A., Research Fellow of the University of Manchester. *Crofton, Aigburth, Liverpool.*

1898, Nov. 29. Hopkinson, Alfred, K.C., M.A., LL.D., Vice-Chancellor of the Victoria University of Manchester. *Fairfield, Victoria Park, Manchester.*

1896, Nov. 3. Hopkinson, Edward, M.A., D.Sc., M.Inst.C.E. *Ferns, Alderley Edge, Cheshire.*

1909, Feb. 9. Howles, Frederick, M.Sc., Analytical and Research Chemist. 20, *Moxley Road, Crumpsall, Manchester.*

1889, Oct. 15. Hoyle, William Evans, M.A., D.Sc., F.R.S.E., Director of the Welsh National Museum, Cardiff. *City Hall, Cardiff.*

1907, Oct. 15. Hübner, Julius, M.Sc.Tech., F.I.C., Lecturer in the Faculty of Technology in the University of Manchester. *Ash Villa, Cheadle Hulme, Cheshire.*

1899, Oct. 17. Ingleby, Joseph, M.I.Mech.E. *Summer Hill, Pendleton, Manchester.*

1901, Nov. 26. Jackson, Frederick. 14, *Cross Street, Manchester.*

1870, Nov. 1. Johnson, William H., B.Sc. *Woodleigh, Altrincham.*

Date of Election.

1878, Nov. 26. Jones, Francis, M.Sc., F.R.S.E., F.C.S. *Manchester Grammar School*, and *Beaufort House, Alexandra Park, Manchester.*

1886, Jan. 12. Kay, Thomas. *Moorfield, Stockport, Cheshire.*

1895, Nov. 12. Kirkman, William Wright. *The Grange, Timperley, Cheshire.*

1903, Feb. 3. Knecht, Edmund, Ph.D., Professor of Tinctorial Chemistry in the School of Technology, Manchester University. *Beech Mount, Marple, Cheshire.*

1902, Feb. 4. Kolp, Noah. *Woodthorpe, Victoria Park, Manchester.*

1893, Nov. 14. Lamb, Horace, M.A., LL.D., D.Sc., Sc.D., F.R.S., Professor of Mathematics in the Victoria University of Manchester. 6, *Wilbraham Road, Fallowfield, Manchester.*

1902, Jan. 7. Lange, Ernest F., M.I.Mech.E., F.C.S. *Fairholm*, 3, *Willow Bank, Fallowfield, Manchester.*

1904, Mar. 15. Lea, Arnold W. W., M.D. 246, *Oxford Road, Manchester.*

1903, Nov. 17. Leigh, Charles W. E., Librarian of the University. *The University, Manchester.*

1907, Oct. 29. Leigh, Harold Shawcross. *Brentwood, Worsley.*

1908, Oct. 20. Liebert, Martin, Ph.D., Managing Director of Meister Lucius, and Brüning Ltd., Manchester. *Swinton House, Withington, Manchester.*

1908, Jan. 14. Littlewood, J. E., B.A., Richardson Lecturer in Mathematics in the University of Manchester. *The University, Manchester.*

1902, Jan. 7. Longridge, Michael, M.A., M.Inst.C.E. *Linkvretten, Ashley Road, Bowdon, Cheshire.*

1857, Jan. 27. Longridge, Robert Bewick, M.I.Mech.E. *Yew Tree House, Tabley, Knutsford, Cheshire.*

1866, Nov. 13. McDougall, Arthur, B.Sc. *Lyndhurst, The Park, Buxton.*

1905, Oct. 31. McNicol, Mary, M.Sc., Research Scholar in the Victoria University of Manchester. 182, *Upper Chorlton Road, Manchester.*

1904, Nov. 1. Makower, Walter, B.A., D.Sc. (Lond.), Lecturer in Physics in the University of Manchester. 214, *Upper Brook Street, Manchester.*

1902, Mar. 4. Mandleberg, Goodman Charles. *Redclyffe, Victoria Park, Manchester.*

Date of Election.

1875, Jan 26. Mann, J. Dixon, M.D., F.R.C.P. (Lond.), Professor of Medical Jurisprudence in the Victoria University of Manchester. 16, *St. John Street, Manchester.*

1901, Dec. 10. Massey, Herbert. *Ivy Lea, Burnage, Didsbury, Manchester.*

1864, Nov. 1. Mather, Sir William, M.Inst.C.E., M.I.Mech.E. *Iron Works, Salford.*

1873, Mar. 18. Melvill, James Cosmo, M.A., D.Sc., F.L.S. *Meole-Brace Hall, Shrewsbury.*

1881, Oct. 18. Mond, Ludwig, D.Sc., Ph.D., F.R.S., F.C.S. *Winnington Hall, Northwich, Cheshire.*

1894, Feb. 6. Mond, Robert Ludwig, M.A., F.R.S.E., F.C.S. *Winnington Hall, Northwich, Cheshire.*

1902, Feb. 18. Moss, William E., B.A. *C/o Messrs. Davies, Benachi & Co., 7, Rumford Street, Liverpool.*

1908, Jan. 28. Myers, William, Lecturer in Textiles in the School of Technology, Manchester University. *Stone Edge, Marple.*

1873, Mar. 4. Nicholson, Francis, F.Z.S. *The Knoll, Windermere, Westmorland.*

1900, April 3. Nicolson, John T., D.Sc., Professor of Engineering in the School of Technology, Manchester University. *Nant-y-Glyn, Marple, Cheshire.*

1884, April 15. Okell, Samuel, F.R.A.S. *Overley, Langham Road, Bowdon, Cheshire.*

1907, Oct. 29. Osborn, Theodore George Bentley, B.Sc., Lecturer in Economic Botany in the University of Manchester. *Windlehurst, Anson Road, Victoria Park, Manchester.*

1892, Nov. 15. Perkin, W. H., Ph.D., M.Sc., F.R.S., Professor Chemistry in the Victoria University of Manchester. *The University, Manchester.*

1901, Oct. 29. Petavel, J. E., B.A., D.Sc., F.R.S., Professor of Engineering in the Victoria University of Manchester. *The University, Manchester.*

1885, Nov. 17. Phillips, Henry Harcourt, F.C.S. *Lynwood, Turton, nr. Bolton, Lancs.*

1903, Dec. 15. Prentice, Bertram, Ph.D., D.Sc., Lecturer in Chemistry, Royal Technical Institute, Salford. *Isca Mount, Manchester Road, Swinton.*

Date of Election.

1901, Dec. 10. Ramsden, Herbert, M.D. (Lond.), M.B., Ch.B. (Vict.). *Sunnyside, Dobeross, near Oldham, Lancs.*

1888, Feb. 21. Rée, Alfred, Ph.D., F.C.S. 15, *Maulderh Road, Withington, Manchester.*

1908, Nov. 3. Reekie, J. A., Manager of the Hayfield Printworks. *Woodhouse, Hayfield.*

1869, Nov. 16. Reynolds, Osborne, M.A., LL.D., F.R.S., M.Inst.C.E. *St. Decuman's, Watchet, Somerset.*

1880, Mar. 23. Roberts, D. Lloyd, M.D., F.R.S.E., F.R.C.P. (Lond.) *Ravenswood, Broughton Park, Manchester.*

1897, Oct. 19. Rothwell, William Thomas. *Heath Brewery, Newton Heath, near Manchester.*

1909, Jan. 26. Russ, Sidney, B.Sc. (Lond.), Demonstrator in Physics in the University of Manchester. 214, *Upper Brook Street, Manchester.*

1907, Oct. 15. Rutherford, Ernest, M.A., F.R.S., Langworthy Professor of Physics in the University of Manchester. 17, *Wilmslow Road, Withington, Manchester.*

1909, Jan. 26. Schmitz, Hermann Emil, M.A., B.Sc., Physics Master at the Manchester Grammar School. 12, *Lime Grove, Chorlton-on-Medlock, Manchester.*

1873, Nov. 18. Schuster, Arthur, Sc.D., Ph.D., F.R.S., F.R.A.S., Honorary Professor of Physics in the Victoria University of Manchester. *Kent House, Victoria Park, Manchester.*

1898, Jan. 25. Schwabe, Louis. *Hart Hill, Eccles Old Road, Pendleton, Manchester.*

1908, Nov. 17. Schwartz, Alfred, A.K.C., M.Sc.Tech., M.I.E.E., Assoc.M.Inst.C.E., Professor of Electrical Engineering in the School of Technology, Manchester University. *Mourne Lodge, Buxton.*

1908, May 12. Scott, Charles Prestwich, M.A. *The Firs, Fallowfield, Manchester.*

1890, Nov. 4. Sidebotham, Edward John, M.A., M.B., M.R.C.S. *Erlesdene, Bowdon, Cheshire.*

1903, April 28. Sidebottom, Henry. *The Hall Cottage, Cheadle Hulme, near Stockport.*

1907, Oct. 15. Simonsen, J. L., M.Sc., Assistant Lecturer in Chemistry in the University of Manchester. 152, *Barlow Moor Road, West Didsbury, Manchester.*

Date of Election.

1906, Oct. 30. Smedley, Ida, D.Sc., Assistant Lecturer in Chemistry in the Victoria University of Manchester. *The University, Manchester.*

1908, Nov. 3. Smith, Charles Frederick, M.Sc.Tech., M.I.E.E., Lecturer in Electrical Engineering in the School of Technology, Manchester University. 10, *Athol Road, Alexandra Park, Manchester.*

1906, Nov. 27. Smith, Norman, D.Sc., Assistant Lecturer in Chemistry in the Victoria University of Manchester. *The University, Manchester.*

1895, Nov. 12. Southern, Frank, B.Sc. 6, *Park Avenue, Timperley, Cheshire.*

1896, Feb. 18. Spence, David. *Lowood, Hindhead, Haslemere, R.S.O., Surrey.*

1901, Dec. 10. Spence, Howard. *Audley, Broad Road, Sale, Cheshire.*

1904, Nov. 1. Stansfield, Herbert, D.Sc. (Lond.), A.I.E.E. 16, *Lonsdale Road, Fallowfield, Manchester.*

1897, Nov. 30. Stromeyer, C. E., M.Inst.C.E. *Steam Users' Association,* 9, *Mount Street, Albert Square, Manchester.*

1905, Nov. 1. Sutcliffe, William Henry, F.G.S. *Shore, Littleborough, Lancs.*

1895, April 9. Tatton, Reginald A., M.Inst.C.E., Engineer to the Mersey and Irwell Joint Committee. *Manor House, Chelford, Cheshire.*

1893, Nov. 14. Taylor, R. L., F.C.S., F.I.C. *Central School, Whitworth Street,* and 4, *St. Werburgh's Road, Chorlton-c.-Hardy, Manchester.*

1906, April 10. Thewlis, Councillor J. H. *Daisy Mount, Victoria Park, Manchester.*

1873, April 15. Thomson, William, F.R.S.E., F.C.S., F.I.C. *Royal Institution, Manchester.*

1896, Jan. 21. Thorburn, William, M.D., B.Sc. 2, *St. Peter's Square, Manchester.*

1896, Jan. 21. Thorp, Thomas, F.R.A.S. *Moss Bank, Whitefield, near Manchester.*

1899, Oct. 31. Thorpe, Jocelyn F., Ph.D., F.R.S., Lecturer and Demonstrator in Organic Chemistry in the Victoria University of Manchester. *The University, Manchester.*

1899, Oct. 17. Todd, William Henry. *Greenfield, Flixton, near Manchester.*

Date of Election.

1909, Jan. 26. Varley, George Percy, M.Sc. (Vic.), Assistant Master in the Municipal Secondary School, Manchester. 18, *Victoria Road, Whalley Range, Manchester.*

1873, Nov. 18. Waters, Arthur William, F.L.S., F.G.S. "*Alderley,*" *McKinley Road, Bournemouth.*

1906, Nov. 13. Watson, D. M. S., B.Sc. *Windlehurst, Anson Road, Victoria Park, Manchester.*

1892, Nov. 15. Weiss, F. Ernest, D.Sc., F.L.S., Professor of Botany in the Victoria University of Manchester. 30, *Brunswick Road, Withington, Manchester.*

1909, Feb. 9. Weizmann, Charles, Ph.D., D.Sc., Senior Lecturer in Chemistry in the University of Manchester. *The University, Manchester.*

1908, May 12. Welldon, Rt. Rev. J. E. C., D.D., Dean of Manchester. *The Deanery, Manchester.*

1907, Oct. 29. Whitehead, Thomas, B.Sc., Chemist to the Manchester Steam Users' Association. 89, *Kenworthy Street, Stalybridge.*

1901, Oct. 1. Wild, Robert B., M.D., M.Sc., M.R.C.P., Professor of Materia Medica and Therapeutics in the Victoria University of Manchester. *Broome House, Fallowfield, Manchester.*

1859, Jan. 25. Wilde, Henry, D.Sc., D.C.L., F.R.S. *The Hurst, Alderley Edge, Cheshire.*

1905, Oct. 31. Willis, Ethel G., M.A., B.Sc., Science Mistress, Manchester High School for Girls. *The High School, Dover Street, Manchester.*

1901, Nov. 26. Wilson, William, M.A. *Carron Vale*, 80, *Fitzwarren Street, Pendleton, Manchester.*

1907, Oct. 15. Winstanley, George H., F.G.S., M.I.M.E., Lecturer in Mining Engineering and Mine Surveying in the University of Manchester. *Wigshaw Grange, Culcheth, near Warrington.*

1909, Jan. 26. Wolfenden, John Henry, B.Sc. (Lond.), A.R.C.S. (Lond.), Assistant Master in the Municipal Secondary School, Manchester. 13, *Pole Lane, Failsworth.*

1903, Oct. 20. Wood, Harry Edwin, B.Sc., Assistant to the Government Meteorological Department, Johannesburg.

1905, Oct. 31. Woodall, Herbert J., A.R.C.S. 32, *Market Place, Stockport.*

1860, April 17. Woolley, George Stephen. *Victoria Bridge, Manchester.*

Date of Election.

1863, Nov. 17. Worthington, Samuel Barton, M.Inst.C.E., M.I.Mech.E. *Mill Bank, Bowdon*, and 37, *Princess Street, Manchester.*

1865, Feb. 21. Worthington, Thomas, F.R.I.B.A. *Broomfield, Alderley Edge, Manchester.*

1895, Jan. 8. Worthington, Wm. Barton, B.Sc., M.Inst.C.E. *Kirkstyles, Duffield, near Derby.*

1897, Oct. 19. Wyatt, Charles H., M.A., *Chelford, Cheshire.*

N.B.—Of the above list the following have compounded for their subscriptions, and are therefore life members:—

Bailey, Charles, M.Sc., F.L.S.
Bradley, Nathaniel, F.C.S.
Brogden, Henry, F.G.S.
Ingleby, Joseph, M.I.Mech.E.
Johnson, William H., B.Sc.
Worthington, Wm. Barton, B.Sc.

HONORARY MEMBERS.

Date of Election.

1892, April 26. Abney, Sir W. de W., K.C.B., D.Sc., F.R.S. *Rathmore Lodge, Bolton Gardens South, South Kensington, London, S.W.*

1892, April 26. Amagat, E. H., For. Mem. R.S., Memb. Inst. Fr. (Acad. Sci.), Examinateur à l'École Polytechnique. *Avenue d'Orléans, 19, Paris.*

1894, April 17. Appell, Paul, Membre de l'Institut, Professor of Theoretical Mechanics. *Faculté des Sciences, Paris.*

1892, April 26. Ascherson, Paul F. Aug., Professor of Botany. *Universität, Berlin.*

1889, April 30. Avebury, John Lubbock, Lord, D.C.L., LL.D., F.R.S. *High Elms, Down, Kent.*

1892, April 26. Baeyer, Adolf von, For. Mem. R.S., Professor of Chemistry. 1, *Arcisstrasse, Munich.*

1886, Feb. 9. Baker, John Gilbert, F.R.S., F.L.S. 3, *Cumberland Road, Kew.*

1888, April 17. Cannizzaro, Stanislao, For. Mem. R.S., Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Chemistry. *Reale Università, Rome.*

1889, April 30. Carruthers, William, F.R.S., F.L.S. 14, *Vermont Road, Norwood, London, S.E.*

1903, April 28. Clarke, Frank Wigglesworth, D.Sc. *United States Geological Survey, Washington, D.C., U.S.A.*

1866, Oct. 30. Clifton, Robert Bellamy, M.A., F.R.S., F.R.A.S., Professor of Natural Philosophy. 3, *Bardwell Road, Banbury Road, Oxford.*

1892, April 26. Curtius, Theodor, Professor of Chemistry. *Universitat, Kiel.*

1892, April 26. Darboux, Gaston, Membre de l'Institut, Professor of Geometry, Faculté des Sciences, Secrétaire perpétuel de l'Académie des Sciences. 36, *Rue Gay Lussac, Paris.*

1894, April 17. Debus, H., Ph.D., F.R.S. 4. *Schlangenweg, Cassel, Hessen, Germany.*

1900, April 24. Dewar, Sir James, M.A., LL.D., D.Sc., F.R.S., V.P.C.S., Fullerian Professor of Chemistry. *Royal Institution, Albemarle Street, London, W.*

Date of Election.

1892, April 26. Dohrn, Dr. Anton, For. Mem. R.S. *Zoologische Station, Naples.*

1892, April 26. Edison, Thomas Alva. *Orange, N.J., U.S.A.*

1895, April 30. Elster, Julius, Ph.D. 6, *Lessingstrasse, Wolfenbüttel.*

1900, April 24. Ewing, James Alfred, C.B., M.A., LL.D., F.R.S., Director of Naval Education to the Admiralty. *Royal Naval College, Greenwich.*

1889, April 30. Farlow, W. G., Professor of Botany. *Harvard College, Cambridge, Mass., U.S.A.*

1900, April 24. Forsyth, Andrew Russell, M.A., Sc.D., F.R.S., Sadlerian Professor of Pure Mathematics. *Trinity College, Cambridge.*

1892, April 26. Fürbringer, Max, Professor of Anatomy. *Universität, Heidelberg.*

1900, April 24. Geikie, James, D.C.L., LL.D., F.R.S., Murchison Professor of Geology and Mineralogy. *Kilmorle, Colinton Road, Edinburgh.*

1895, April 30. Geitel, Hans. 6, *Lessingstrasse, Wolfenbüttel.*

1894, April 17. Glaisher, J. W. L., Sc.D., F.R.S., Lecturer in Mathematics. *Trinity College, Cambridge.*

1894, April 17. Gouy, A., Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Physics. *Faculté des Sciences, Lyons.*

1900, April 24. Haeckel, Ernst, Ph.D., Professor of Zoology. *Zoologisches Institut, Jena.*

1894, April 17. Harcourt, A. G. Vernon, M.A., D.C.L., F.R.S., V.P.C.S. *St. Clare, Ryde, Isle of Wight.*

1894, April 17. Heaviside, Oliver, F.R.S. *Homefield, Lower Warberry. Torquay.*

1892, April 26. Hill, G. W. *West Nyack, N.Y., U.S.A.*

1888, April 17. Hittorf, Johann Wilhelm, Professor of Physics. *Polytechnicum, Münster.*

1892, April 26. Hoff, J. van't, Ph.D., For. Mem. R.S., Professor of Chemistry. 2, *Uhlandstrasse, Charlottenburg, Berlin.*

1892, April 26. Hooker, Sir Joseph Dalton, G.C.S.I., C.B., O.M., D.C.L., F.R.S., Corr. Memb. Inst. Fr. (Acad. Sci.). *The Camp, Sunningdale, Berks.*

Date of Election.

1869, Jan. 12. Huggins, Sir William, O.M., K.C.B., LL.D., D.C.L., F.R.S., F.R.A.S., Corr. Memb. Inst. Fr. (Acad. Sci.). 90, *Upper Tulse Hill, Brixton, London, S.W.*

1892, April 26. Klein, Felix, Ph.D., For. Mem. R.S., Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Mathematics. 3, *Wilhelm Weber Strasse, Göttingen.*

1894, April 17. Königsberger, Leo, Professor of Mathematics. *Universität, Heiaelberg.*

1892, April 26. Ladenburg, A., Ph.D., Professor of Chemistry. 3, *Kaiser Wilhelm Strasse, Breslau.*

1902, May 13. Larmor, Sir Joseph, M.A., D.Sc., LL.D., Sec. R.S., F.R.A.S. *St. John's College, Cambridge.*

1892, April 26. Liebermann, C., Professor of Chemistry. 29, *Matthäi-Kirch Strasse, Berlin.*

1887, April 19. Lockyer, Sir J. Norman, K.C.B., F.R.S., Corr. Memb. Inst. Fr. (Acad. Sci.). *Science School, South Kensington, London, S.W.*

1902, May 13. Lodge, Sir Oliver Joseph, D.Sc., LL.D., F.R.S., Principal of the University of Birmingham. *The University, Birmingham.*

1900, April 24. Lorentz, Henrik Anton, Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Physics. *Hooigracht, 48, Leyden.*

1892, April 26. Marshall, Alfred, M.A., Professor of Political Economy. *Balliol Croft, Madingley Road, Cambridge.*

1901, Apri 23. Metschnikoff, Élie, D.Sc., For.Mem.R.S. *Institut Pasteur Paris.*

1895, April 30. Mittag-Leffler, Gösta, D.C.L. (Oxon.), For. Mem. R.S., Professor of Mathematics. *Djursholm, Stockholm.*

1894, April 17. Murray, Sir John, K.C.B., LL.D., D.Sc., F.R.S. *Challenger Lodge, Wardie, Edinburgh.*

1902, May 13. Osborn, Henry Fairfield, Professor of Vertebrate Palæontology. *Columbia College, New York, U.S.A.*

1894, April 17. Ostwald, W., Professor of Chemistry. *Groszbothen, Kgr. Sachsen.*

Date of Election.

1899, April 25. Palgrave, Sir R. H. Inglis, F.R.S., F.S.S. *Henstead Hall, Wrentham, Suffolk.*

1894, April 17. Pfeffer, Wilhelm, For. Mem. R.S., Professor of Botany. *Botanisches Institut, Leipsic.*

1892, April 26. Poincaré, H., For. Mem. R.S., Membre de l'Institut, Professor of Astronomy. 63, *Rue Claude Bernard, Paris.*

1892, April 26. Quincke, G. H., For. Mem. R.S., Professor of Physics. *Universität, Heidelberg.*

1899, April 25. Ramsay, Sir William, K.C.B., Ph.D., F.R.S., Professor of Chemistry in University College, London. 12, *Arundel Gardens, Notting Hill, London, W.*

1886, Feb. 9. Rayleigh, John William Strutt, Lord, O.M., M.A., D.C.L. (Oxon.), LL.D. (Univ. McGill), F.R.S., F.R.A.S., Corr. Memb. Inst. Fr. (Acad. Sci.). *Terling Place, Witham, Essex.*

1900, April 24. Ridgway, Robert, Curator of the Department of Birds, U.S. National Museum. *Brookland, District of Columbia, U.S.A.*

1897, April 27. Roscoe, Sir Henry Enfield, B.A., LL.D., D.C.L., F.R.S., V.P.C.S., Corr. Memb. Inst. Fr. (Acad. Sci.). 10, *Bramham Gardens, Earl's Court, London, S.W.*

1902, May 13. Scott, Dukinfield Henry, M.A., Ph.D., F.R.S., F.L.S. *East Oakley House, Oakley, Hants.*

1892, April 26. Sharpe, R. Bowdler, LL.D., F.L.S., F.Z.S. *British Museum (Natural History), Cromwell Road, London, S.W.*

1892, April 26. Solms, H., Graf zu, Professor of Botany. *Universität, Strassburg.*

1886, Feb. 9. Strasburger, Eduard, D.C.L., For. Mem. R.S., Professor of Botany. *Universität, Bonn.*

1895, April 30. Suess, Eduard, Ph.D., For. Mem. R.S., For. Assoc. Inst. Fr. (Acad. Sci.), Professor of Geology. 9, *Africanergasse, Vienna.*

1892, April 26. Thiselton-Dyer, Sir W. T., K.C.M.G., C.I.E., M.A., Sc.D., Ph.D., LL.D., F.R.S. Lately Director Royal Botanic Gardens, Kew. *The Ferns, Witcombe, Gloucester.*

Date of Election.

1895, April 30. Thomson, Sir Joseph John, M.A., Sc.D., F.R.S., Professor of Experimental Physics. 6, *Scrope Terrace, Cambridge.*

1894, April 17. Thorpe, Sir T. E., C.B., Ph.D., D.Sc., LL.D., F.R.S., V.P.C.S. *Government Laboratory, Clement's Inn Passage, Strand, London, W.C.*

1894, April 17. Turner, Sir William, K.C.B., M.B., D.C.L., F.R.S., F.R.S.E., Professor of Anatomy. 6, *Eton Terrace, Edinburgh.*

1886, Feb. 9. Tylor, Edward Burnett, D.C.L. (Oxon), LL.D. (St. And. and McGill Univs.), F.R.S., Professor of Anthropology. *Museum House, Oxford.*

1894, April 17. Vines, Sidney Howard, M.A., D.Sc., F.R.S., Sherardian Professor of Botany. *Headington Hill, Oxford.*

1894, April 17. Warburg, Emil, Professor of Physics. *Physikalisches Institut, Neue Wilhelmstrasse, Berlin.*

1894, April 17. Weismann, August, Professor of Zoology. *Universität, Freiburg i. Br.*

1888, April 17. Zirkel, Ferdinand, For.Mem.R.S., Professor of Mineralogy. *Konigstrasse 2a, Bonn am Rhein.*

CORRESPONDING MEMBER.

1850, April 30. Harley, Rev. Robert, Hon. M.A.(Oxon), F.R.S., F.R.A.S., Hon. Memb. R.S. Queensland. *Rosslyn, Westbourne Road, Forest Hill, London, S.E.*, and *The Athenæum Club, London, S.W.*

Awards of the Wilde Medal under the conditions of the Wilde Endowment Fund.

1896. Sir GEORGE G. STOKES, Bart., F.R.S.
1897. Sir WILLIAM HUGGINS, K.C.B., F.R.S.
1898. Sir JOSEPH DALTON HOOKER, G.C.S.I., C.B., F.R.S.
1899. Sir EDWARD FRANKLAND, K.C.B., F.R.S.
1900. Rt. Hon. LORD RAYLEIGH, F.R.S.
1901. Dr. ÉLIE METSCHNIKOFF, For.Mem.R.S.
1903. Prof. FRANK W. CLARKE, D.Sc.
1905. Prof. CHARLES LAPWORTH, LL.D., F.R.S.
1908. Prof. JOSEPH LARMOR, D.Sc., LL.D., Sec.R.S.

Awards of the Dalton Medal.

1898. EDWARD SCHUNCK, Ph.D., F.R.S.
1900. Sir HENRY E. ROSCOE, F.R.S.
1903. Prof. OSBORNE REYNOLDS, LL.D., F.R.S.

Awards of the Premium under the conditions of the Wilde Endowment Fund.

1897. PETER CAMERON.
1898. JOHN BUTTERWORTH, F.R.M.S.
1899. CHARLES H. LEES, D.Sc.
1900. Prof. A. W. FLUX, M.A.
1901. THOMAS THORP.

THE WILDE LECTURES.

1897. (July 2.) "On the Nature of the Röntgen Rays." By Sir G. G. STOKES, Bart., F.R.S. (*28 pp.*)

1898. (Mar. 29.) "On the Physical Basis of Psychical Events." By Sir MICHAEL FOSTER, K.C.B., F.R.S. (*46 pp.*)

1899. (Mar. 28.) "The newly discovered Elements; and their relation to the Kinetic Theory of Gases." By Prof. WILLIAM RAMSAY, F.R.S. (*19 pp.*)

1900. (Feb. 13.) "The Mechanical Principles of Flight." By the Rt. Hon. LORD RAYLEIGH, F.R.S. (*26 pp.*)

1901. (April 22.) "Sur la Flore du Corps Humain." By Dr. ÉLIE METSCHNIKOFF, For.Mem.R.S. (*38 pp.*)

1902. (Feb. 25.) "On the Evolution of the Mental Faculties in relation to some Fundamental Principles of Motion." By Dr. HENRY WILDE, F.R.S. (*34 pp., 3 pl.*)

1903. (May 19.) "The Atomic Theory." By Professor F. W. CLARKE, D.Sc. (*32 pp.*)

1904. (Feb. 23.) "The Evolution of Matter as revealed by the Radio-active Elements." By FREDERICK SODDY, M.A. (*42 pp.*)

1905. (Feb. 28.) "The Early History of Seed-bearing Plants, as recorded in the Carboniferous Flora." By Dr. D. H. SCOTT, F.R.S. (*32 pp., 3 pl.*)

1906. (March 20.) "Total Solar Eclipses." By Professor H. H. TURNER, D.Sc., F.R.S. (*32 pp.*)

1907. (February 18.) "The Structure of Metals." By Dr. J. A. EWING, F.R.S., M.Inst.C.E. (*20 pp., 5 pls., and 5 text-figs.*)

1908. (March 3.) "On the Physical Aspect of the Atomic Theory." By Professor J. LARMOR, Sec. R.S. (*54 pp.*)

1909. (March 9.) "On the Influence of Moisture on Chemical Change in Gases." By Dr. H. BRERETON BAKER, F.R.S. (*8 pp.*)

LIST OF PRESIDENTS OF THE SOCIETY.

Date of Election.	
1781.	Peter Mainwaring, M.D., James Massey.
1782-1786.	James Massey, Thomas Percival, M.D., F.R.S.
1787-1789.	James Massey.
1789-1804.	Thomas Percival, M.D., F.R.S.
1805-1806.	Rev. George Walker, F.R.S.
1807-1809.	Thomas Henry, F.R.S.
1809.	*John Hull, M.D., F.L.S.
1809-1816.	Thomas Henry, F.R.S.
1816-1844.	John Dalton, D.C.L., F.R.S.
1844-1847.	Edward Holme, M.D., F.L.S.
1848-1850.	Eaton Hodgkinson, F.R.S., F.G.S.
1851-1854.	John Moore, F.L.S.
1855-1859.	Sir William Fairbairn, Bart., LL.D., F.R.S.
1860-1861.	James Prescott Joule, D.C.L., F.R.S.
1862-1863.	Edward William Binney, F.R.S., F.G.S.
1864-1865.	Robert Angus Smith, Ph.D., F.R.S.
1866-1867.	Edward Schunck, Ph.D., F.R.S.
1868-1869.	James Prescott Joule, D.C.L., F.R.S.
1870-1871.	Edward William Binney, F.R.S., F.G.S.
1872-1873.	James Prescott Joule, D.C.L., F.R.S.
1874-1875.	Edward Schunck, Ph.D., F.R.S.
1876-1877.	Edward William Binney, F.R.S., F.G.S.
1878-1879.	James Prescott Joule, D.C.L., F.R.S.
1880-1881.	Edward William Binney, F.R.S., F.G.S.
1882-1883.	Sir Henry Enfield Roscoe, D.C.L., F.R.S.
1884-1885.	William Crawford Williamson, LL.D., F.R.S.
1886.	Robert Dukinfield Darbishire, B.A., F.G.S.
1887.	Balfour Stewart, LL.D., F.R.S.

* Elected April 28th; resigned office May 5th.

1888-1889.	Osborne Reynolds, LL.D., F.R.S.
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1909-1910.	Francis Jones, M.Sc., F.R.S.E.

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(Issued separately, November 19th, 1908).

II. Some Properties of the Radium Emanation. By Professor E. Rutherford, F.R.S. - - - - - - - - - - pp. 1—2.
(Issued separately, November 19th, 1908).

III. A Method of Calculating the Number of Degrees of Freedom of a Molecule among which the Partition of Energy is governed by the Principal Temperature. By H. Bateman, M.A. *7 Text-figs.* - - - - - - - - - - - - - - pp. 1—9.
(Issued separately, December 3rd, 1908).

IV. Notes on the Spawning of *Eledone*, and on the Occurrence of *Eledone* with the Suckers in Double Rows. By F. H. Gravely, M.Sc. *2 Plates* - - - - - - - - - - - pp. 1—14.
(Issued separately, December 28th, 1908).

V. On the Local Intensification of Draught produced in a Horizontal Air Current by the Presence of an Inclined Rod. By A. H. Gibson, M.Sc. - - - - - - - - - - - pp. 1—10.
(Issued separately, December 24th, 1908).

VI. On the Production of White Ferrous Ferrocyanide. By R. L. Taylor, F.C.S., F.I.C. - - - - - - - - - - pp. 1—2.
(Issued separately, December 31st, 1908).

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VII. The Volatility of Radium A and Radium C. By Walter Makower, B.A., B.Sc. *2 Text-figs.* - - - - - - - - - pp. 1—8.
(Issued separately, January 15th, 1909).

VIII. The Dawn of Human Intention. An Experimental and Comparative Study of Eoliths. By Prof. Alfred Schwartz and Sir Hugh R. Beevor, Bart., M.D. *7 Text-figs.* - - - - - - pp. 1—34.
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(Issued separately, April 7th, 1909).

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(Issued separately, April 21st, 1909).

XV. The Use of Wind by Migrating Birds. By F. Stubbs. (Communicated by T. A. Coward, F.Z.S.) - - - - - - - pp. 1—9.
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